SCIENTIFIC AMERICAN

No. SUPPLEMENT 569

Scientific American Supplement, Vol. XXII., No. 569. Scientific American, established 1845. | NEW YORK, NOVEMBER 27, 1886. | Scientific American Supplement, $5 a year. Scientific American and Supplement, $7 a year.

THE DISASTER AT THE CRARAE QUARRIES.

On Saturday, September 25, according to annual custom, a company numbering upward of 1,000 persons, and including several members of the Glasgow Corporation, their wives and families, proceeded on board the Lord of the Isles steamer to Loch Fyne, to witness the great blast at the Crarae quarries. The quarries are situated on the face of a hill, rising 150 ft. perpendicularly from the loch. The steamer gave the signal for the explosion by blowing her whistle. Seven tons of powder were fired, and seventy thousand tons of rock were dislodged. It was reckoned a most successful blast, and thus far all went well. But then the passengers were anxious to land and inspect the scene of operations. Some three hundred of them did so, and all who could squeeze in entered the quarry. At first nothing untoward happened, but after a few minutes one visitor after another fell motionless to the ground, overpowered by the noxious vapors which the explosion had generated. A quarryman had, it seems, given them warning of their danger, but his words were either misunderstood or disregarded. Nearly a hundred persons were thus prostrated, and of these seven died on the spot, while others remained in a critical condition for several days. It is remarkable that the mephitis vapors did not begin to ooze out from the crushed rock until some time after the blast. This no doubt lulled the visitors into a false sense of security. The above, together with our first page cut, is from the London *Graphic*. Our second picture is from *The Illustrated London News*, which gives the following: The singular accident that proved fatal to seven persons, three or four of them well-known citizens of Glasgow, on Saturday, Sept. 25, has been briefly noticed. It occurred at the Crarae quarries, on the west shore of Loch Fyne, a few miles below Inverary; which are the largest in Scotland, and supply the best granite for street paving. They are the property of Messrs. W. Sim & Co., and are leased by Messrs. A. & J. Faill & Co., Glasgow, contractors. It has been the yearly custom to have a great blast at the quarries, the quantity of gunpowder used increasing to above six tons on recent occasions. The Corporation of Glasgow are the largest customers of the lessees. The Lord Provost of Glasgow and the members of the Corporation were always invited guests, and excursionists from all parts of the west of Scotland came to witness the spectacle.

On the 25th of Sept., the Clyde steamer Lord of the Isles brought a company of a thousand, and a pleasant passage was enjoyed down the river through the Kyles of Bute and up Loch Fyne.

The quarries are situated on the face of a hill, which rises almost perpendicularly from the edge of the loch to a height of about 150 ft. The blast was prepared by a chamber being bored in the face of the rock at a distance of 30 ft. from the water level, and extending inward 60 ft., with branch chambers of 20 ft. each in length to the left and right, starting from the innermost point of the main chamber. These cavities were filled with the charge, which was exploded by electricity. The steamer arrived off the quarries shortly after one o'clock, and was brought up a mile from the shore. The signal for the explosion was given by the steamer sounding her steam whistle. The charge of seven tons of powder was immediately fired; in less than a minute the whole face of the quarry heaved outward, between sixty and seventy thousand tons of rock being dislodged, the operation proving quite successful. Part of the company, about three hundred, then landed to inspect the quarry, accompanied by the proprietor, Mr. W. Sim, the lessees, Messrs. A. & J. Faill, and the manager, Mr. Sharp. A few minutes after entering the quarry, they were affected by the fumes of carbonic acid gas and sulphurous oxide, remaining from the explosion of the gunpowder, and still pouring out from the crannies and recesses, and from under the loose fragments of shattered stone. More than eighty persons fell prostrate, mostly insensible, and six gentlemen died on the spot. The others, being removed as quickly as possible, and carried back by the steamer, gradually revived in the fresh air, except one, who died at the Greenock Infirmary. The following is the list of the killed: Councilor John Young, Glasgow; Councilor Thomas Duncan, Glasgow; Mr. Matthew Waddell, City Restaurant, Glasgow; Mr. Steel, jeweler and electro-plater, Ann Street, Belfast; Mr. Peter Stevenson, optician, Forest Road, Edinburgh; Mr. James Shaw, son of Councilor Shaw, Glasgow; Mr. Small, Dalry, Ayrshire.

The above strange occurrence has been paralleled in this country by the accident recorded in the next paragraph.

1. The quarry, looking from the lake. 2. Interior of the quarry.

CRARAE QUARRY, LOCH FYNE, SCOTLAND.—SCENE OF THE LATE REMARKABLE ACCIDENT.

A REMARKABLE RAILWAY ACCIDENT.

A recent accident at Perkasie, Pa., tunnel shows the importance of their ventilation. The above tunnel is about half a mile long. Repairs are being made therein. On the 3d inst. some fifty men were at work near the center of the tunnel, when a freight engine, unable to draw its train through the tunnel, became "stalled" near the place where the men were at work. Fresh coal was put in the locomotive furnace, and the fan blast set in motion. Soon the train started, when it acted as a piston in a cylinder, driving the gases from the furnace before it; and when the gases struck the men who were working in the tunnel, they nearly all fell as if dead. With no premonition, about forty of them became almost instantly unconscious, and fell as they stood.

One of the men, only partially affected, made his way to the tunnel entrance and gave the alarm. A gravel train, with flat cars, happened to be standing there. It was run in to the place of the accident, and the bodies of the fallen men were dragged upon the cars and taken out to the fresh air. All were supposed to be dead, but, to the surprise of the rescuers, the recently dead men soon began to show signs of life, and in a short time all were themselves again, except one poor fellow, who died, and who, in his fall, sank into a pool of water, and probably was drowned.

One of the unconscious men was found hanging on a ladder, head downward, suspended by his feet.

AN INTERVIEW WITH M. CHEVREUL, THE CENTENARIAN.

The eminent French chemist Chevreul attained the age of 100 years on the 31st of last August, and the occasion was celebrated by the students of Paris, among whom he is a great favorite, and by the French people generally, with great enthusiasm. The publishers of the *Journal Illustre*, of Paris, availed themselves of the opportunity to make a report of the old man's conversation in a manner that marks an era in this line of journalistic enterprise. Not only were his words taken down verbatim, but his various attitudes while speaking were photographed by the instantaneous process, and engraved. The number of the *Journal* of September 5 is entirely devoted to the subject, and 12 engravings are given, exhibiting the old man while speaking, thus making up altogether the most vivid report of a personal "interview" on record.

The importance of M. Chevreul in the scientific world, and the useful lessons of hygiene and philosophy to be derived from his conversation, which is full of youthful animation and wit, justifies us in translating the most salient portions of it as follows, the interviewer being M. Nadar.

THE SECRET OF LONGEVITY.

M. Nadar.—You were speaking just now, M. Chevreul, of the fables that so often gain currency regarding celebrated persons. It is thus you are said to have discovered a chemical secret of longevity, as Flamel, in his alembics, is said to have discovered the secret of making gold.

M. Chevreul.—You demand a secret? I must commence, then, by telling you that there is no secret of longevity, but there is, as in all things else, a method.

M. N.—There are many people who would like to know this method.

M. C.—It is easy to learn, but I think that with many people it would be difficult to follow. Nevertheless, as all things material or spiritual are to be had for a price, it is plain that whoever would gain a blessing should first of all strive to merit it.

M. N.—Do you, then, regard long life as a blessing?

M. C.—Do you doubt it?

M. N.—Certainly not in a case like yours. It was of such a life, I think, that the Persian poet said, "He whose life is full of useful deeds will never be weary of

old age;" but for us common mortals the ills seem to more than counterbalance the pleasures.

M. C.—How do you arrive at this conclusion?

M. N.—How can we avoid being discouraged in view of the sum of human good in comparison with the sum of evil? I confess, if I may presume to speak of myself in your presence, that life is already becoming intolerable to me in view of the sufferings of man and the torture of the brute. It tempts me to justify the Spartan practice of putting the aged to death.

LONG LIFE A BLESSING.

M. C.—Sparta had not the advantages of our civilization; and you forget that it was not only the aged, but also the infirm, that paganism claimed the right to destroy. But without entering into a line of discussion that would lead us astray from that which you have said would interest you, I hold that, balancing all the good and evil, life is a blessing, and I am grateful for it.

M. N.—Very well for you, M. Chevreul, but is your life a normal one? It is not easy to find a centenarian. To find one endowed with all the faculties in so eminent a degree is an event that does not occur once in a century.

M. C.—There is no reason why that which you consider an exception should not become the common lot of all. Yet we must not exaggerate nor pretend that every individual well advanced in years may preserve in the same degree his faculties. Certainly it cannot be denied that with the advance of years the vital forces, both physical and intellectual, lose their power. But it is also true that this loss has its compensations. The calmness of age tends to meditation, and fixes the mind upon serious things. The habit of observation, far from being extinguished with age, serves the purpose of reflection, and aids in the modification of old and the development of new ideas. And since there is no greater enjoyment for man than that which is found in the search for truth, we cannot doubt that there is happiness in the prolongation of life.

M. N.—If it were possible to impart to every human being this noble curiosity which has characterized your whole existence, I would indeed accede to your theory; but permit me to observe that, even under the most favorable conditions, the use and fatigue of the faculties causes the most cruel diseases. Students of sedentary habits are so severely afflicted by physical suffering that, in spite of the will, they lose all intellectual freedom. What then?

But this inheritance of longevity, however encouraging it may seem, could not suffice if one did not insure it by following in his own life the habits of those from whom he derived his capacity of living. It is necessary for each one to study his personal aptitudes, and conform to them with a constant firmness. Every regime is personal. Nothing is more difficult than to pronounce in the name of science upon the nutritive property of this or that aliment, because of the great difference existing in the idiosyncrasies of individuals. And here I invoke my personal experience. Every member of my family drank wine, while I from my infancy to the most advanced age have experienced an invincible repugnancy to it. Whenever I have drunk it I have suffered with pains in the stomach, and even vomiting, while for the generality wine is an excellent and often indispensable aliment. Locke and Newton drank only water, also Haller, and still others. I have never drunk anything but water, and nevertheless I am president of the Vintage Society of Anjou, but honorary president only.

M. N.—And have you drunk beer?

M. C.—Never. But the word "never" is not quite exact. Recently, during my convalescence after the little accident that happened to me, one of my medical friends came and advised me to put a little beer into the water which I drank. I consented to put a few drops of beer into each glass of water, and I found myself neither better nor worse for it. But after a week the bottle was still three-quarters full, and the contents had become unfit to drink. It was necessary to throw it away, and I beg that no one shall ever offer me any more.

M. N.—And liquors, brandy?

M. C.—I have often found the odor of it agreeable, but could never decide to drink it. If the aroma of a liquor pleases me, I pour two or three drops into the palm of my left hand, and rub it with the palm of my right hand, inhale the vapor, and that is all.

M. N.—As to tobacco?

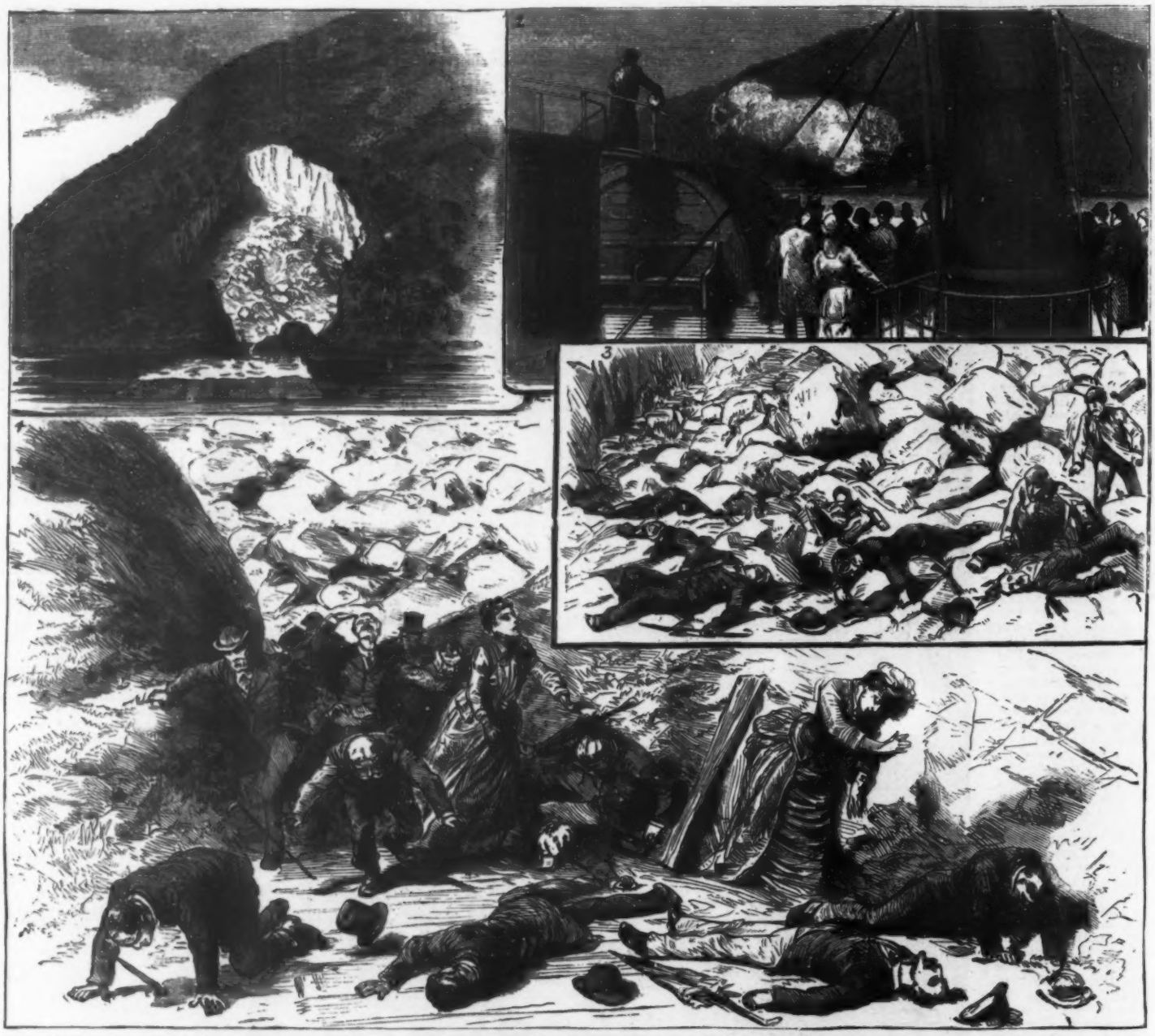
M. C.—No tobacco. The odor of it has always disturbed me to such an extent that my son Henry, now 68 years old, and a great smoker, carefully avoids bringing any odor of tobacco into my presence, and I thank him for it. But I cannot too much insist upon this essential point, that what is suitable for one may not be proper for another. It is, then, important for each one to note well what is adapted to his own constitution. Thus I have the same aversion to all kinds of fish as to fermented liquors, especially to wine; also a distaste for a large number of vegetables, and I could

EVERY TRUE REGIME IS PERSONAL.

M. C.—I cannot too often repeat that we should not exaggerate, and that we should especially guard against drawing general conclusions from particular cases; yet it is nevertheless true that the study of particular cases may and should conduct us to general precepts. And since you have questioned me concerning myself, I will say that I have always observed that we may act an important part in the preservation of hereditary qualities. My father, Dr. Chevreul, died in 1845, at the age of ninety-one and one-half years. My mother, who also came of a medical family, died at the age of ninety-three.

M. C.—It becomes, then, our duty to guard against such evils as far as in us lies. Have you not often been struck with the fact that the larger proportion of the human race die of disease, and not of old age? Have you looked into the cause of this fact, and have you considered its consequences?

M. N.—It is quite evident that we do not know how to conduct our lives, and that there is in the fact which you have just stated an indication of a method to be followed. But what is this method?



1. Crarae Quarry, from the Loch. 2. Passengers watching the blast from the Lord of the Isles. 3. Quarrymen bringing out the bodies. 4. The rush from the quarry.

THE DISASTER AT THE CRARAE QUARRY, LOCH FYNE, SCOTLAND.—[See first page]

THE DEAN OF STUDENTS.

It is because such personal facts are continually presenting themselves to our observation that every man should regard himself as a student all his life, because he should strive all his life to become more capable, better. The thirst for knowledge is the point of departure of all science. Progress, far from diminishing, only increases this desire. We should never for a moment forget that man is endowed with the capacity for endless improvement. He is the only perfectible animal, and this is why I have always cherished, as the most beautiful of my titles, that of Dean of Students.

RULES OF LIFE.

As to the details of my life. I maintain a barometric exactness and regularity in all the habits of my daily life. I eat at fixed hours, taking my time, masticating well, and leaving the table with still some appetite for more; and you have seen, nevertheless, that I do not

make a wry face at the sight of food and that I do not leave my plate full. But let us remember the words of the wise man, "The belly has slain more men than war," and that the Spartans proscribed those citizens who were too fat.

HE USES LITTLE SALT OR SPICES.

I use little salt or spices, and but little coffee, and I flee as from a pest from all those excitants of which I feel no need, and from all alcoholics, in whatever form they may present themselves.

NO DISCUSSION AT THE TABLE.

I think it wise to vary one's occupations, and divide the day, giving, for example, the morning to exact science, the middle of the day to philosophy, the evening to poetry and music. But above all, no discussion at the table. It has justly been said that a discussion while eating is a cushion of needles in the stomach, and Montesquieu has well shown that one should only eat with a calm spirit. Let the dining room remain the dining room, and never be turned into a room for argument.

POLITICS AN IDLE PROFESSION.

It is not necessary to add that politics should never be discussed at table, nor anywhere else, as far as I am concerned. Politics is an indolent occupation, which devolves upon those who have no legitimate employment. It is the profession of those who have no profession. It arrives at no conclusion, while scientific observation, in the moral as in the material world, solves all things. Time devoted to politics is lost time. I confess that I have kept myself more and more away from it, to such an extent that since 1871 I have never opened a newspaper, except, of course, our scientific journals and reviews. Politics deals in rhetoric and in an empty philosophy of the present moment, which only confuses and wearies the mind. In general, the number of words concerning a thing are numerous in proportion as the knowledge of the thing is limited. I think it wise to hold one's self aloof from all discussions that present no real and tangible interest, and that lead only to dissension and divisions. Buffon truly says that most men lead a life of contention, and that in reality many die of worry and vexation.

FACTS THE BASIS OF OPINION.

The knowledge of facts is the true basis of opinion. Man determines his own destiny by the observation of the natural phenomena which exist around and within him. I have the greatest respect for Leibnitz, the great observer, who has justly been compared to Newton, but I dissent absolutely from his saying that "The senses were given to man only to deceive him." Such a belief would lead us to regard the visible creation as only an appearance without reality. Our immortal Moliere answers it in his "Forced Marriage," where the philosopher, or rather sophist, Marphurius advocates this system of denial, and will not permit Sganarrelle to assert either that he is or that he is not there, which so provokes Sganarrelle that he appeals to a club, which proves conclusively that he is present, for there is nothing doubtful about a blow from a cudgel.

M. N.—I see that you greatly admire Moliere.

M. C.—Moliere, of all men, knew best human nature, thanks to his mental analysis and synthesis, of which he made such admirable use. He applied it to the knowledge of man as Newton applied mathematical analysis and synthesis to the study of the celestial mechanism, and thus both attained to the highest human glory. But in what I have just said about Leibnitz I would not diminish the esteem in which he is held, for his ideas were often more elevated than even those of Aristotle and Plato; and let me add that I am far from assigning to great men their relative positions after the manner of a schoolmaster who has assigned to his pupils a task in composition.

Let us not forget the consequences of erroneous formulas in the growth of opinion. A single error engenders others still worse, and so on indefinitely. Hence we should carefully guard against affirming anything of which we have not positive evidence. M. Pasteur has well said that the worst mental habit is that of believing things because we wish them to be true.

M. N.—I know your admiration for M. Pasteur, whose useful labors I have long admired.

M. C.—M. Pasteur is for me one of the greatest geniuses of the century. The reason is that our savants have generally proceeded from the known to the unknown, while his method has been the reverse of this. I must say in all humility, that the school to which I belong would never have tolerated his method. The curing of one malady by inoculating another would have been regarded as an absurdity.

I have never been, thank God! a pessimist.

I am happy in believing that there are other friends of truth than myself, and that they share with me the idea of eternal justice.

Some say because they do not understand a thing, that it does not exist, and that is what they call the positive philosophy, as if that which was denied yesterday may not be found true to-day, and that which is believed true to-day may not be found false to-morrow.

To those who deny because they cannot understand I would say: "Can you comprehend the idea of space, either with or without limits? No; nor I either. Very well; if, now, following your example, I deny the existence of space because I do not understand it, what will you say of my conclusion? Has science revealed to you the entire secret of the universe? Science sees phenomena, the mind sees causes. What does comparative anatomy teach us? Does it prove that man is descended from the apes? Am I the son of an orang-outang? Never!"

OF PHOTOGRAPHY.

M. N.—You knew Daguerre well?

M. C.—Yes; and I remember how interested he was in my experiments. He said to me, "You explain to me that which I before knew only by instinct." As to the daguerreotype, or even the photograph, I confess that I experienced for a long time a veritable aversion to it. Up to 1883, that is to the age of 97, I refused all invitations to sit for a picture, but I was vanquished at last, and I will tell you how. I had entered a carriage to go to the Institute, when a gentleman approached me most politely. "M. Chevreul," said he, "you can render me an immense service." I objected to the lateness of the hour. He insisted, and demanded permission to accompany me in my carriage, in order to explain to me. Scarcely was he seated when he said to me, "Monsieur, it is in your power to secure my fortune or my ruin. I am a photographer." I started, but he added: "The Emperor of Brazil insists upon having your portrait, and if I make it, my fortune is assured." In the name of the Emperor of Brazil, I yielded. You know Dom Pedro is a true savant, and conferred upon me the order of the Rose.

A FIRST CAUSE.

M. N.—Permit me a question. You have, during your whole life, insisted upon the experimental method in all research. You believe nothing without proof. You demand the evidence of sight and touch How, then, can you believe, as you do, in a first and intelligent cause, which is a pure abstraction?

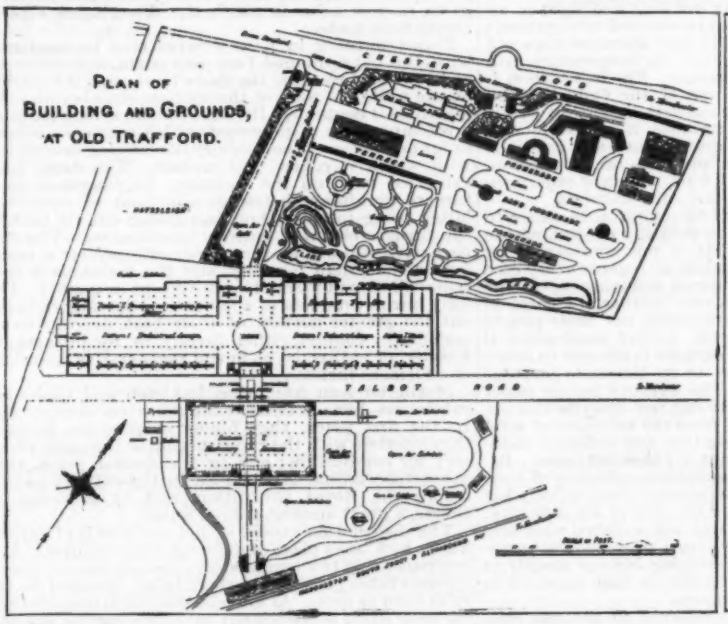
M. C.—An abstraction! No. This grand fact of life is incomprehensible, much less explicable, without assuming a first and intelligent cause.

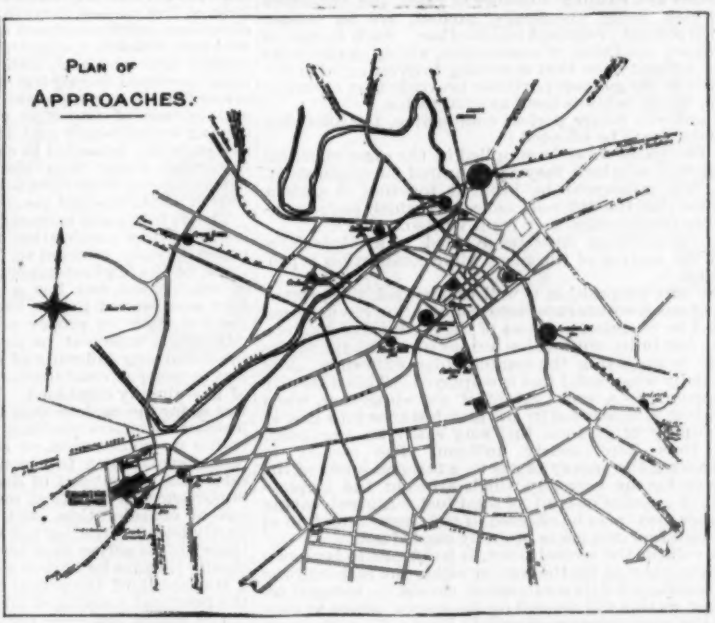
If the atheist pretends that the advocate of the existence of God maintains a hypothesis which it is impossible to demonstrate, I reply by asking the atheist to demonstrate his own hypothesis. What is man, considered as a mortal, in comparison with the universe without? Compare the sublime spectacle of the universe which man has not created with that which his own efforts have produced—with human society, which is the product of the only perfectible being on earth, endowed with free will and illuminated with the moral sense, yet ever at war with his kind, from the most savage to the most civilized state, so that it may well be said that the chief enemy of mankind is man! Yet they tell us that it is for the interest of man to destroy the religious sentiment. I realize all that society would thus lose, but I see no gain. The conditions of human life are not so good that we may venture upon a thing that may make them worse.

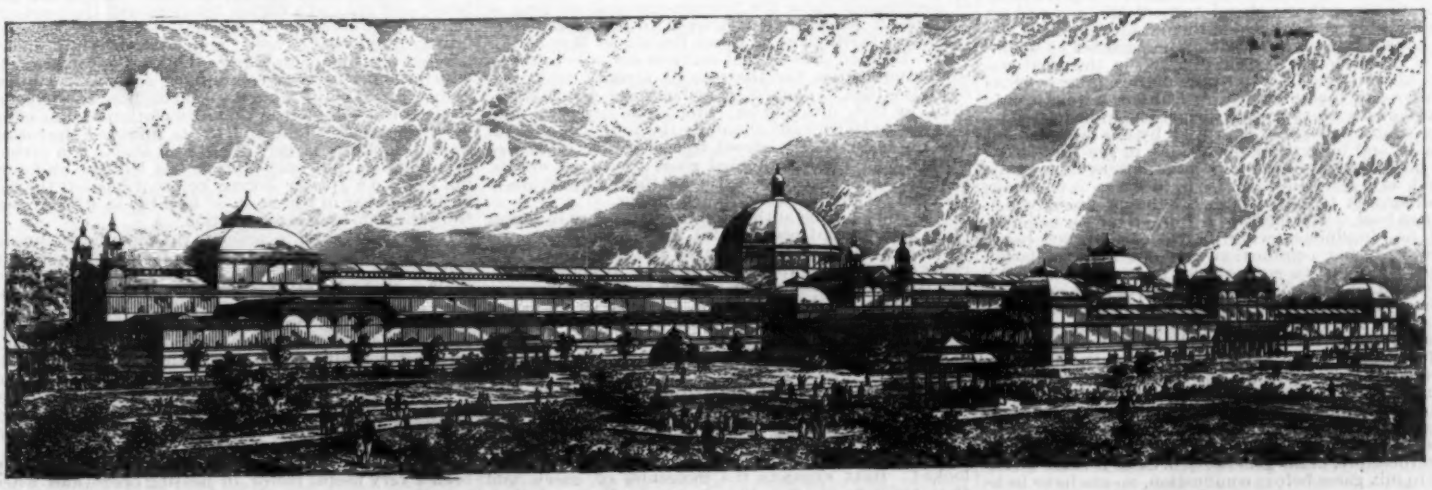
You who pretend to write for the good of humanity and to illuminate the world with the light of truth, denouncing religion as a superstition, wait before I accept your views until you have something better than the sentiment of hope with which to console a mother for the loss of her son; with which to sustain an unfortunate stricken by poverty and pain; with which to cheer the fallen one who repents, or to soften the last hours of the criminal stricken by the justice of the law. Ah, do not tell me that all this is an abstraction! How many things are invisible and yet not less real. We see and believe by virtue of the divine light that which the natural eye cannot discern.

MANCHESTER JUBILEE EXHIBITION.

WE publish a perspective view of the adopted design for the buildings of the Royal Jubilee Exhibition, to be held at Old Trafford, Manchester, next year, together with a ground plan and key to approaches. It is by Messrs. Maxwell & Tuke, of Manchester and Bury, Lan-







SELECTED DESIGN FOR THE ROYAL JUBILEE EXHIBITION, MANCHESTER. 1887.

cashire, and was recently selected in competition. The buildings consist of a central nave 1,022 ft. long and 56 ft. high, with a transept across the center 370 ft. long and the same height, and two lower transepts near the ends of the nave 60 ft. wide. At the intersection of the nave with the central transepts is a polygonal dome, 90 ft. diameter and 140 ft. high, and at the intersection of the nave with the low transepts are square pavilions. The spaces between the naves and the arms of the cross are filled with exhibition courts in bays 30 ft. wide. The machinery in motion will be provided for in a large annex, separated from the main building by a 70 ft. roadway, with a covered fireproof gallery of communication. The section devoted to fine arts is completely isolated from the main building by stout brick walls, with iron sliding fireproof doors; the brick walls will be covered inside with Parian cement. Messrs. Neill & Sons, Manchester, have taken the contract for erection at £34,350.—*Building News.*

COMBUSTION.

ON COMBUSTION WITH SPECIAL REFERENCE TO PRACTICAL REQUIREMENTS.*

By FREDERICK SIEMENS, C.E., London.

IN all heating operations, the main object is to produce the greatest amount of effective work with economy of fuel, material, and labor. In order to do this, it is of the utmost importance that combustion should be as perfect as possible. This, however, would not alone in all cases meet practical requirements, the form and dimensions of the furnace and many other points having also to be considered.

The author read a paper two years ago before this Institute, in which he described a method of working regenerative gas furnaces by employing radiant heat alone within the heating chamber. On that occasion he drew attention for the first time to an important point connected with combustion, which he proposes to treat more particularly on the present occasion, namely, that a flame requires free space for development, if it is to burn properly and effectively. He then showed, from results obtained in practice, that a flame burning within an inclosed space should be directed so that while in active combustion it does not come into contact either with the sides or roof of the furnace, or with the materials contained therein; as when flame is allowed free space in which to burn, and is not interfered with by solid bodies, not only is there an increase of the work performed, but that work is accomplished in a better manner, and a considerable saving of fuel, furnace material, and other advantages are realized.

Since that time this system of applying radiant heat, which it is now preferred to describe under its more general term as heating with free development of flame, has been largely adopted, and the author's theoretical investigations have been borne out by the results of practical experience.

It is necessary in an investigation of this kind to commence with a consideration of combustion from a theoretical point of view; and the theory which best explains the nature of flame is the one by which it is regarded as a rushing together of gases, the molecules of which, being chemically excited, are in violent motion toward or against one another. Such motion is a primary condition of combustion, which cannot take place without it, so that anything interfering with the motion of the gaseous particles prevents that chemical union which exhibits itself as combustion.

In order to insure perfect combustion, the following means have to be adopted:

I. The gases must be supplied in the exact chemical proportion in which they are required for combustion.

II. The gases must be brought together in such a manner that the different molecules which have to enter into combination may readily do so.

III. Everything must be avoided which interferes with the motion of the gases while combustion is proceeding.

The first proposition is well understood, the proportion of gases which enter into combination having been settled by chemical analyses of the products of combustion; but in its application serious practical difficulties occur in supplying the combustibles uniformly, more especially when solid fuel is employed. This difficulty disappears, to a great extent, if not altogether, when solid fuel is converted in the first instance into gas, as the supply of gaseous fuel may easily be regulated, and thus kept nearly uniform. The facility of controlling the supply of gas to a furnace is one of the reasons for the economy which arises in the employment of gaseous instead of solid fuel. A great saving of labor may also be effected if the transformation of the solid fuel into gas is properly carried out.

As regards the second point, it is difficult to lay down any general rule for the way in which the fuel, and the air necessary for its combustion, should be brought together, as this will depend on the special object in view and the particular work which has to be performed. Theoretically, a thorough mixture of the gas and air before combustion, of which the best example is the well known Bunsen burner, may be regarded as a solution of this difficulty; but in practice, in the great majority of cases, such a complete mixture is for various reasons quite inadmissible. A Bunsen burner is only advantageous when a small surface has to be heated by direct contact of flame, as proved by the incandescent gaslight and by certain operations in the laboratory and household; while when large spaces have to be heated, as is generally the case in furnaces, it is always advantageous to use a large luminous flame which radiates heat. The flame of a Bunsen burner being almost non-luminous, owing to free carbon not being liberated during combustion, has but little radiating power, and must in consequence transmit its heat by direct contact only. The transmission of heat by means of direct contact of flame is in most cases unsuitable, as was shown in the author's paper already referred to. It is wasteful, and tends very much to destroy or injure the furnaces in which it is used, as well as the materials operated upon. Although the Bunsen burner appears so simple from a theoretical point of view, and is undoubtedly found to be so in practice for certain purposes, it is quite unfit for most metallurgical operations, especially those conducted upon a large scale.

As, therefore, in the generality of cases it is not advisable to mix gases before combustion, means have to be adopted to bring them together as rapidly as possible at the beginning of combustion. It is also necessary that the resulting flame should have a high radiating power, as it is by the radiation of the flame that heat is best transmitted to the walls and roofs of furnaces and to the material under treatment.

Furnaces in which solid fuel is burnt necessarily produce radiant heat in the ordinary or natural process of combustion, but the real cause of the efficiency of such furnaces does not seem to have been appreciated, although it was known from experience that the only coals fit to be used in them were those supplying large quantities of heavy carbureted hydrogen gas, liberating in combustion much carbon, which tends to produce a luminous flame. The very best coke was found to be entirely unfit for the same purpose, although the highest temperature can be obtained by its use, if the materials to be heated are inserted in the incandescent coke itself, as is proved by the melting of steel in pots by the old method.

There is no particular difficulty in producing radiant heat in ordinary furnaces if proper coal is employed; but it is quite otherwise where gas is used, and in the regenerative gas furnace the manner in which the gases are brought together is a matter of the greatest importance. If the mixture is too intimate, a short flame is produced, having great heating but very little radiating power, whereas if the gases do not properly combine, perfect combustion cannot take place. A great loss of heat is thus occasioned, together with other disadvantages, which will be referred to later. A mean between these is what is required, whereby good combustion is secured, producing intense heat, and at the same time a flame of great radiating power.

The way in which the gas and air should be brought together for combustion depends upon various circumstances—chemical, physical, structural, and economical—such as the quality of the gas employed, the temperature required, the size of the furnace chamber, and the particular work to be performed. The gas is generally supplied through a horizontal slit in the side of the furnace chamber, above which the air enters through a similar slit of somewhat greater area, overlapping the gas port on either side. Gas being of lower specific gravity than air tends to rise through it, while the air sinks into the gas, thus securing in most cases a sufficient mixture.

The efficiency of this arrangement greatly depends upon the relative temperature of the gas and air, the specific gravity of gases being very much affected by their temperature. If, for instance, air only is heated before admission into the furnace chamber, the specific gravities of the hot air and cold gas will be more nearly equal, and the gases not permeating one another, no proper mixture can take place, and, consequently, combustion will be imperfect, causing a great reduction in the working power of the furnace, with other resulting disadvantages.

It will be interesting to consider for a moment the cause of flame becoming luminous. This luminosity is due to free carbon, liberated by the hydrocarbons in the flame, being heated up to the temperature of the flame itself. These solid particles, becoming incandescent, act like tiny incandescent gas lights, each particle of free carbon throwing out heat and light in all directions, until consumed and converted into carbonic acid gas, which is transparent, and therefore does not radiate light and heat, although its temperature may have increased during the change. The free carbon is always the last component part of the flame to burn, and, in cases of imperfect combustion, instead of becoming incandescent and luminous, it is precipitated as soot when deposited in chimney flues, and as smoke if carried along with the products of combustion, which, issuing from chimney tops, is so very objectionable in our towns and manufacturing districts.

The third means necessary for adoption in order to insure perfect combustion formed the subject of the paper already referred to. It is not considered, by itself, of the highest importance as regards every case of combustion, but has a direct influence upon the first and second points, because neither the employment of gases in proper proportion, nor their proper mixture, is sufficient to insure perfect combustion if the disturbing influence of surfaces is allowed to interfere to prevent combination, or to dissociate particles of gas already combined. The author's former paper was so far incomplete that it did not describe the objectionable effects resulting from the influence of solid bodies on combustion, or contain any sufficient theoretical explanation to account for that influence. Besides this, the subject of dissociation, which is of such importance in practical metallurgy, was entirely left out of consideration, partly because of its difficulty, partly because the author was not satisfied with any theory of its action that had been proposed, but principally because he wished to confine himself mainly to a statement of the actual results he had obtained in the practical working of furnaces.

The author has since fully referred to the influence of dissociation upon the temperature and working of furnaces, in a lecture he delivered to the members of the Royal Institution of Great Britain in May of this year. He then showed that surfaces not only interfere with combustion, for the reasons already explained, but also that, if heated, they facilitate dissociation; that, in fact, dissociation, which has hitherto been thought to be brought about by the influence of heat alone, was in reality caused by the action of heated surfaces upon the combined gases; or, at all events, that, in the absence of surfaces, the temperature of dissociation would be very much higher.

It would lead the author too far if he were to repeat upon the present occasion all the circumstances and considerations which led him to the conclusion then brought forward. He would propose to confine himself to a few points which appear to him sufficiently conclusive. In the first place, it must be explained that nearly all the physicists who have experimented on dissociation have made use of small vessels or tubes, of special material, which had to be heated to the temperature at which dissociation of the gases experimented upon would set in. Although the particular materials chosen—mostly clay, porcelain, or asbestos—have no direct chemical action on the dissociated gases, yet the influence of surfaces in general, and especially of highly heated surfaces, have been entirely overlooked. Heat expands the molecules of gases, and thus tends to weaken the chemical affinity of their atoms, until, at a certain high temperature, expansion overpowers chemical attraction, and dissociation takes place; but if highly heated surfaces are present which tend to attract or condense one or other of the elements constituting the gas experimented upon, dissociation is facilitated, and will necessarily occur at a much lower temperature.

That this is a correct theory is confirmed by the circumstance that, if the vessels or tubes used for the experiments are made of rough or porous materials, or, still better, if they are filled with rough or porous material, such as broken porcelain or asbestos, dissociation is much facilitated. Until, therefore, experiments intended to prove dissociation are made in an open space containing no heated surfaces, it will be impossible to ascertain the real temperature of dissociation, all calculations hitherto made being too low. The highest dissociation temperatures which have been recorded are those of Professor Bunsen, and he obtained them mainly because his experiments did not require heated surfaces; but even his results cannot be considered correct, as the cold inner surfaces of the tubes in which he exploded the gases prevented their perfect combustion for the reasons already stated. Still, the Bunsen experiments are of the highest value as indicating the means by which real dissociation temperatures may be arrived at. This was explained in the author's lecture at the Royal Institution, and illustrated by diagrams. Copies of the lecture are at the disposal of those members of the Iron and Steel Institute who wish to consider the subject further.

Hitherto physicists have been satisfied to prove dissociation by showing that a flame became longer with increase of temperature. It was maintained that, as the temperature of the flame increased, dissociation set in more and more, thus causing an extension of the flame, combustion and dissociation being repeated over and over again. As this was really the case, the experiment was so far conclusive, only the real cause of the dissociation which took place was not sufficiently understood.

The experiments made to prove dissociation by an increase in the length of the flame, having been made in narrow tubes, like the other experiments, were influenced by the action of the inner surfaces, which action is mainly the cause of this kind of dissociation, as is proved when the dissociating influence of the surfaces is removed. This is the case in the regenerative gas burner which has been set up and lighted. It will be observed that while the flame is comparatively cool it is long, whereas with increase of temperature the flame becomes gradually shorter and whiter, thus illustrating the fact that a flame, as its temperature increases, becomes shorter if it is not impeded by surfaces which prevent combustion and help dissociation.

This burner is supplied with ordinary town gas, and serves to show the effects which may be produced when all the means available to insure perfect combustion are taken advantage of. Nothing has been done to the burner since it was lighted, the gas supply remains as it was, and the chimney being independent of the flame, which burns free, all conditions remain constant except the temperature; this becomes very intense, much higher, indeed, than that of the flame burning in the narrow tubes in which the dissociation experiments were made.

Flame burning in narrow tubes may be compared with the old-fashioned furnace system, and taken as an example of working the flame by causing it to strike on the walls and roof of the furnace chamber and the materials it contains. By these means a long flame of low temperature is produced, which may even extend as far as the top of the chimney, destroying everything with which it comes into contact. The flame here exhibited may, on the contrary, be compared to a furnace working with free development of flame, the latter being intensely hot, and giving out its heat in the furnace chamber entirely by radiation. The furnace itself will not be injuriously affected for a much longer time than formerly, and the materials it contains will show a marked improvement in quality. The fully burnt products of combustion, having radiated out the greater portion of their heat, deposit the remainder by contact, either directly, as, for instance, in a boiler, or indirectly, as in the regenerative chambers of a Siemens furnace.

It will be seen from what has been said that solid substances have a twofold influence on combustion. In the first place, they hinder combustion, because they interfere with the rapid motion of the gases necessary for combustion; and in the second place, they cause dissociation, as explained in the author's lecture before the Royal Institution, and by so doing, of course, a great amount of heat is lost.

The dissociation caused by hot surfaces is of various kinds, and takes place at different temperatures. At a comparatively low temperature, dissociation of hydrocarbons takes place, the carbon being liberated in the solid form as soot. At a moderately high temperature, carbonic oxide is dissociated into solid carbon and carbonic acid gas; at a higher temperature, the products of combustion begin to dissociate, steam splitting up into hydrogen and oxygen; and, lastly, at a still higher temperature, depending upon the kind of surface with which the products of combustion come into contact, carbonic acid splits up into solid carbon and oxygen. From this it will be seen that dissociation has the effect of setting carbon free, and to its influence the formation of smoke is largely due. This smoke is a serious disadvantage, not only after it has left the chimney, but even to a greater degree before it has left the furnace chamber in which it is formed, as will be seen from the following consideration.

It has been found in practice that in a large furnace where a voluminous flame impinges on the sides and roof and on the material it contains, even that part of the flame which is not in direct contact with the surfaces does not radiate out nearly its full amount of heat. As flame is quite transparent for light and heat, the inner surfaces of the furnace chamber, and the materials it contains, ought to get the full benefit of the radiative power of this part of the flame, and that this is not the case can only be explained by the circumstance that these surfaces are enveloped in a dense cloud of dissociated carbon, which prevents the heat rays from reaching the surfaces.

There can be no doubt that radiant heat has always been a very useful factor in heating operations whenever the construction of the furnaces, etc., admitted of it. But the author believes he has shown in the above

* Read at the London meeting of the Iron and Steel Institute.

remarks that sufficient attention has not hitherto been paid to the very detrimental effect on combustion itself, as well as on the work done, when the radiative power of the flame is in any way interfered with, so that it cannot be developed to its fullest extent. He hopes also to have made it clear that complete combustion is impossible whenever the live or active flame is allowed to come into contact with any solid surface, and that such solid surface will always suffer when so impinged upon—not, as has been hitherto believed, by the action of heat alone, but also by the mechanical and chemical action of such flame.

As flame is nothing but molecular motion of combining gases, this circumstance alone proves the necessity of not interfering with such motion, while the moving molecules, although indefinitely small, are so numerous, and move so rapidly, that they represent an amount of energy which, acting constantly, must in time destroy any surface or object exposed to it; besides which, the flame has most probably a chemical influence that tends to assist this process of destruction.

The author wishes to draw attention to the gas burner exhibited, which was fully described at a meeting of the Gas Institute, and is similar in principle to the regenerative gas burners brought out some years ago, which are now manufactured in various forms, and used extensively for lighting purposes. This particular burner is designed for warming rooms by means of radiant heat in the same way as the ordi ary English fire. There is, however, this difference between the two—that with this burner heat is radiated in a more useful manner, being distributed uniformly throughout the room. Very active ventilation is insured by its use, it is not expensive to maintain—consuming about 50 cubic feet of gas a day, which is sufficient to warm a small sitting room—and is especially economical as regards labor, as no handling of coals, ashes, or soot is required, and smoke is entirely avoided.

In an ordinary fireplace, the heat which is not radiated out into the room, but is carried away with the products of combustion into the chimney, is lost; while it is utilized in this case to heat the air required for combustion, whereby the temperature, and, consequently, the heat-radiating power, of the flame is much increased. This process goes on in a progressive ratio, for as the temperature of the flame increases, so does that also of the air supplied to the burner, and thus it can be safely asserted that nearly all the heat produced by combustion is eventually radiated into the room.

The author has exhibited this burner at work, and has drawn so much attention to it, because it gives the best possible illustration of the conditions under which combustion can alone be perfect. It also shows to how great an extent radiant heat can be applied, and how important a part it plays in all operations of warming, heating, and transmitting heat. For these reasons the author recommends this burner to the consideration of the members as supplying information in the best and most easy manner regarding the requirements of large furnaces, with which it is so difficult to make experiments and obtain data.

In each case the flame is not permitted to come into direct contact with any surfaces whatever, while the heat still remaining in the non-luminous products of combustion is abstracted by direct contact in the regenerators, heating the air required for combustion, which air, being non-luminous, can only be heated by direct contact, as radiant heat has no effect in heating air, just as heated air cannot be made use of to supply radiant heat. The analogy being so perfect, it will be readily seen how well the requirements of combustion for the production of radiant heat can be studied by means of this little burner.

It is by means of radiant heat alone that nature warms us, and thus becomes the source of the development of all organic and inorganic matter. We should imitate nature, and employ radiant heat for artificial warmth, as well as in the arts and manufactures.

CHAIN CASTING.

THE PROCESS EMPLOYED IN CASTING BRASS CHAINS IN JEYPORE, RAJPUTANA.*

By MR. C. PURDON CLARKE, Keeper of the Indian Collection, South Kensington Museum.

IN June last, at the request of your president, I had the honor of giving a general description of certain processes employed in making fine brass castings in Upper India, illustrating my paper by showing some finished pieces and moulds. One object, a double linked chain anklet, was then but imperfectly described, owing to the want of examples of the manufacture in its various stages. I therefore wrote for further details to Surgeon-Major Hendley, the physician to the Residency at Jeypore, and now propose reading a description sent by him: The peculiar anklet known as *santh*, made up of flat links formed at one casting, is produced in Southern Rajputana and Central India, and especially at Sawia Madhopore, a Jeypore town beneath the famous fort of Ranthambhor, which stands in the hills near the junction of the Banas and Chambal Rivers.

Here twenty-five men obtain a livelihood in making these ornaments. Their ancestors brought the art from Bundi a hundred years ago. The anklet is termed *sant* or *santh*, from Hindoo words signifying joining or sticking. Three different varieties of the *santh* are made at Sawia Madhopore: (1) *Sut wan santh*, in which the pattern is of plain or thread-like links. (2) *Chakti dar santh*, having small patches or projections upon its edge. (3) *Kil kunda-ki santh*, in which the ornaments are fastened by a screw. The following is a description of the process of manufacturing a plain *santh*, variety 1.

Several specimens were made in the writer's presence. A composition is prepared of seven parts of wax, forty parts of resin or *rat*, eleven parts of oil of sesamum. These ingredients are well mixed and melted together in an earthen pot. The mixture is then poured through a fine cloth into another vessel, which is nearly full of cold water. It falls to the bottom in a thick mass, which is then pulled and repulled in the fashion of making barley sugar, and again dropped into cold water.

A portion of it is next taken and rolled out with a flat wooden tool on a board, in such a way as to form, from one end of the cylinder, a long thin string of the thickness of the future links of the *santh*. A stick, having the same diameter as the proposed links, is taken, and the thin wax cord is coiled round it from near one end to the other. A straight cut is next made along one edge of the spiral, by which a number of rings, open at one side, are formed. A knife edge is made hot in a charcoal fire, and by applying the ends of the rings to it they can be easily united. One ring is first formed, and then the second linked into it. The two edges of the third ring are passed over the first two and joined.

The fourth ring, in like manner, passes through the two preceding it, and thus the process is continued, until perhaps sixty or seventy rings are used—a sufficient number to make an ordinary anklet. When a curbed chain of the requisite length has been thus formed, it is flattened out on a board, and the ends united. The workman takes the anklet in his hands, and rapidly moves it through his fingers, and presses the links together in such a way as to make the ornament firm, flat, and regular. He uses warm or cold water, as may be necessary, to insure that the wax maintains a suitable pliancy.

A solution of red clay is prepared in the following manner: Red clay three parts, dried cowdung one part, with sufficient water. The first two ingredients are powdered, and made into a paste with water. The wax *santh* is dipped in the composition, so that the fine clay adheres to every part of the links. As soon as the coat becomes dry the operation is repeated, in all four or five times. A thicker paste, composed of red clay (not strained) sixteen parts, fresh cowdung two parts, water one part, is spread over the *santh*, so as to form a mould.

Three coatings are required. When the mould is dry, the upper edge is scratched with an iron tool, so as to expose the wax links within. The links are oiled, and a flat thin piece of wax is attached to them all along the edge by means of a hot wire. All the inequalities are removed by careful scratching, and the whole covered with the clay paste, which is allowed to dry as before. A quarter of an inch of the top of the *santh* is left uncovered by the clay, and to the portion of the wax thus exposed is attached a thicker ribbon of the same material an inch long, a quarter of an inch broad, and the sixth of an inch thick. The top band, the ribbon, and the links are thus continuous, though the latter are quite separate from each other. Two *sanths* are cast together, and for this purpose are so placed that the leading rods on each anklet are next each other. The two end ribbons are close together at the top.

Three distinct coatings of the thick paste of red clay are now applied over the pair of *sanths*, so as to form one ring-like mould, which ends in a boss or projection over the end ribbons. To prevent cracking of the moulds and loss of metal, a coating of thick black earth, mixed with chaff in the proportion of thirty-two parts of the former to one of the latter, is applied over the whole mould, and the top over the projection containing the ribbons is formed into a cup. The mould is now ready for casting. The metal usually employed is a composition termed *dharkree*, *phut*, or *bharat* by the workmen; *kansi* or bell metal by the public. It is composed of sixteen parts of brass and six of zinc. Another mixture is made of sixteen parts of the above mass with four additional parts of zinc. A third consists of old and broken anklets. The melting is done in a small conical cup termed *mus*, which is made of black potter's earth.

A sufficiency of metal is taken and placed in pieces in the *mus* with a small quantity of borax. (For a *santh* of one seer, one and a quarter seers must be used to admit of wastage.) The *mus* thus filled is inverted over the top of the cup-shaped head of the mould in which the wax ends of the ribbons have been exposed, and the edges of the two are united by the black earth and chaff composition. A small opening is also made in the mould near the top, by means of a style, to allow of the escape of the wax. The kiln is simply an open furnace, or pit in the ground, filled up with dried cowdung cakes.

The moulds are placed in this and made red hot. After a time the wax escapes in black fumes, and the metal melts. When the metal is quite melted, blue fumes appear. The moulds are kept upright, the inverted *mus* being at the bottom. They are removed in this position, and cracks from which fumes escape are carefully plastered over with clay, and the whole dipped for an instant in cold water. The mould is now inverted, and the melted metal poured into the cavity from which the wax has been burnt out. All that remains is to take out the ornament when the mould is cool, to break off the leading rods and ribbons, and to file away any inequalities or adhesions which may prevent free movement of the links. A *santh* made of *dharkree* is of a yellow color. If of equal parts of the above and of old anklets, it will be white.

The latter variety only is made at Sawia Madhopore. When the *santh* is finished, it may be plated with a composition of pewter, or *rang*, forty parts, hydrochlorate of ammonium, or *nausadar*, one part. The pewter is made of three parts of zinc and two of lead. A small portion of the composition is applied to each *santh* by heat, and the anklet is then cleaned and brushed with cold water. One man can make twenty-five pairs of *sanths* in fifteen days, at a cost of five rupees for fuel and labor and five rupees for metal. He does nothing else, and sells the ornaments himself at from eight to ten annas a pair.

He requires about one and a half maunds of charcoal to make twenty-five pairs of *sanths*. The above description is accompanied by a set of Indian ink drawings showing the founders at work and several examples of the anklets and moulds in various stages. In the first illustration is shown the melting and preparation of the wax, in the second rolling it into thin rods. In the third this rod is twisted round the stick, to form even sized links; the fourth shows making up the links into chain; the fifth applying the moulding earth to the wax model; the sixth firing the moulds, and the seventh the moulds after firing, with sections showing their internal structure.

I have only to add that there is a seeming omission in the description of the firing, also in the corresponding drawings. It seems probable that, like other furnaces I saw in various parts of India, some form of bellows communicating with the hearth should be used to intensify the fire, the ordinary heat of burning cowdung not being sufficient to melt the mass of metal.

Dr. Hendley, the writer of the above notes, is the founder of the Science and Art Museum at Jeypore, Rajputana. This institution is connected with the local school of art, where technical teaching is carried to the extent of actual manufacture. Many curious processes are, therefore, from time to time brought to notice, which would otherwise sooner or later join the long list of the lost arts of antiquity. The two samples have been examined by Mr. Edgar Jackson, who has kindly furnished me with the following analysis: The brass contains: tin 3·53, lead 3·49, copper 46·33, zinc 45·98, iron 0·76. The pewter is composed of tin 38·16, lead 61·74, and a trace of copper.

* Read before the Iron and Steel Institute.

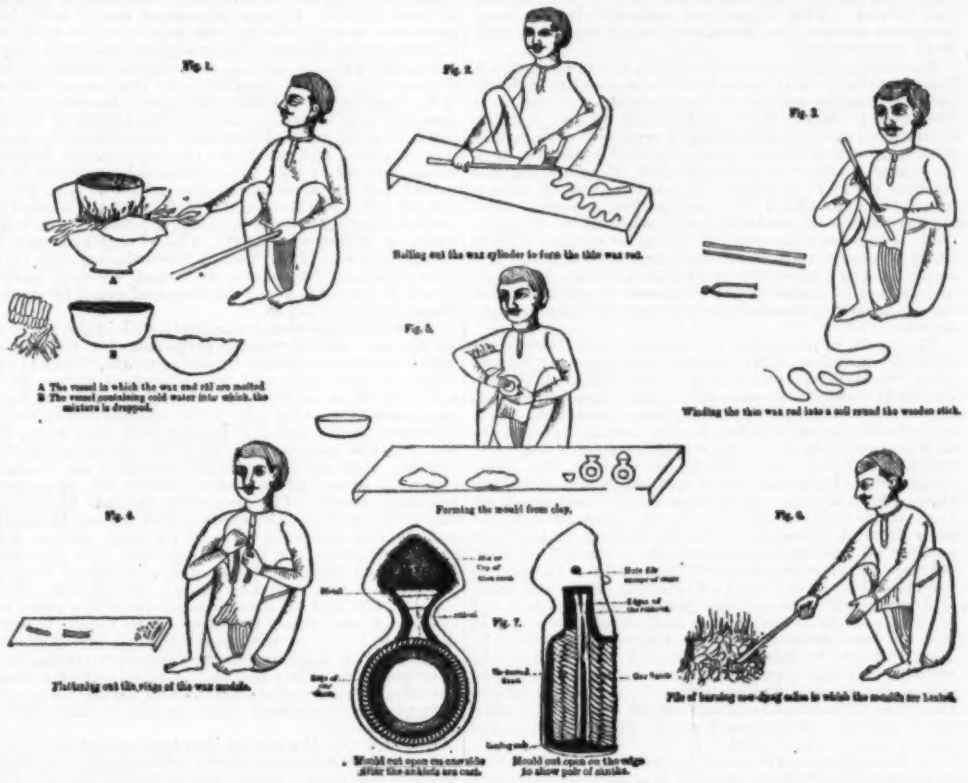


Fig. 1.
Fig. 2.
Fig. 3.
Rolling out the wax cylinder to form the thin wax rod.
Winding the thin wax rod into a coil round the wooden stick.
Fig. 4.
Fig. 5.
Fig. 6.
Forming the mould from clay.
Fig. 7.
Mould cut open on one side after the anklets are cast.
Mould cut open on the edge to show pair of anklets.

THE EAST INDIAN METHOD OF CASTING BRASS CHAINS.

ON THE CASTING OF CHAINS IN SOLID STEEL.

By M. FERD. GAUTIER, Paris.

FOR a number of years past, there has been an increased tendency to substitute steel, in one or other of its forms, for wrought iron. Hitherto, however, the chain manufacture has resisted the encroachments of steel to a larger extent than most other departments of the trade. This has been due to the necessity that has hitherto existed for welding the links, since it appeared to be difficult to apply steel to this purpose. Some years ago experiments were made by MM. David

and Demoiseau, of Paris, with a view to casting chains in steel, and so to get rid of the process of welding in that industry.

A bar of soft steel, cut in the form of a plate, was made to assume the shape of two elongated rings, tied together by a flat piece, and this became the origin of the link. It was found that, in curving such bars in the form of a U, it was possible to tie them together through the two elongated rings, and so make a continuous connection. The experiment, however, was only partially successful. The weight of the chain was not much reduced, as compared with wrought iron, by the alteration of form. The links were moved more stiffly, and they were not so easily curved in different directions, especially on a small radius. Another serious difficulty was that of catching a link in such a way as to stop the falling of a chain cable or other chains used in the merchant marine.

Another process of manufacturing chains, and which possesses the advantage of allowing the usual form of the links to be retained, is as follows: A steel bar rolled into the form of a section resembling a cross—being similar to two cross links in horizontal projection—is drilled and cut with suitable tools into the form of an ordinary weldless chain. This process, however, involved a great deal of work and much loss of metal in reducing the bars to the form of links, so that it could not be regarded as economical. In other respects it might have become established as a good process. The true solution of the problem would appear to be that of producing a moulded or cast chain. This seems to be possible with certain descriptions of metal, when the shrinkage is moderate, but otherwise numerous cracks would be likely to occur in the links. At the last meeting of the Institute, an endless curb chain of Indian manufacture, cast in bronze or brass at a single operation, was shown by the President; and at the Inventions Exhibition last year a chain was exhibited, of large size, cast in Delta metal, and of very small shrinkage indeed. This chain was intended for a large Brazilian cruiser, the Riachuelo, which was constructed in this country.

The casting of chains in solid steel, however, appears, theoretically at any rate, to be a somewhat difficult process, having regard to the conditions which it is necessary to fulfill, viz.: (1) In order to arrive at an economical product which could compete successfully with ordinary wrought iron, weight for weight, it is necessary to have a quick method of moulding the chains. (2) It is necessary to employ steel of such a character as to afford the most perfect security—steel that is quite solid, and absolutely without blow holes. (3) It is necessary to avoid all cracks or similar defects likely to result from the shrinkage of the metal. Absolute security must also be provided in this direction, otherwise the chains would obviously be quite unfitted for use in so important an employment as the merchant marine.

The problem presented for solution was therefore a difficult one, but MM. Joubert and Leger, of Lyons, have succeeded in overcoming all the difficulties involved by the use of a process which combines chilled casting and instantaneous removal from the moulds. I. A chilled casting, or, in other words, casting the metal in an iron mould, is obviously, when practicable, both the readiest and the most economical process, the work being reduced to a cleaning of the moulds and scrubbing them with graphite. This labor can be performed by boys or by women, and special or experienced workman are not necessary. Chilled casting is the best method of retaining unaltered the structure of steel which was originally without blow holes. It is easy, for example, to get a solid soft steel, if silicon and manganese are added in suitable proportions; but it is not always possible to maintain it in that condition if it is cast into complicated shapes by the use of sand moulds. This difficulty is due to the action of the metal on the moulds, in which gases are occluded that are unable to escape before solidification takes place. The adoption, therefore, of a chilled casting, which secures the minimum amount of action between the metal and the mould, must be preferred.

II. Instantaneous removal from the moulds is another point of importance, which it is absolutely necessary to attend to in producing chains with a metal having so high a shrinkage as steel. This is the only method whereby the links can become free to contract, and by which cracks can be got rid of. In carrying ont this process, a link, having been previously cast, is kept in a vertical position through an iron casting block, which is in two pieces, one of them lying upon the other in a horizontal position. At the end of this block there is a casting hole, used as a head to feed the casting. This part of the mould may be made in sand, in order to keep the steel liquid for a longer period than it would be if cast in iron, should such a course be rendered necessary by the special character of the steel employed. The instantaneous removal from the moulds is done through three blocks or taps, which are connected with a shaft that may have an oscillating movement, depending upon a hand beam. Two of these blocks are so arranged as to act on the two ends of the upper part of the mould, which they can thereby raise, whereas the third block, being connected with the lower part of the mould, can let it down. Thus, by the simple movement of a hand lever, the mould may be opened, and the casting is thereby directly liberated, so as to cool and shrink.

The same result could, of course, be obtained by the use of hydraulic power acting on three cylinders, so arranged as to operate together in opposite directions. The finishing of the chain is quite a simple process. Several casting blocks are placed on a revolving turntable, or it may be on a truck rolling on wheels. It is possible to cast several pieces of chain together, each cast adding a link. After the opening of the moulds, a workman cuts the head off the link, and afterward files the cut, if that should be necessary. The links are subsequently placed in a vertical position, and the casting is continued as before.

The chain having been completed in this way, it is annealed and hardened in oil, if necessary, after which it is ready to be tested. It appears superfluous to describe the advantages of a process so simple and so quickly performed as that just referred to. The process is one that opens up a new field for the successful employment of the highest qualities of steel—such steel as can be trusted to remain solid and without blow holes when cast in chilled moulds. Crucible steel generally would be suited to this purpose, and probably also the *mitis* metal, the high manganese steel, and chrome steel.

If, by this process, better chains can be manufactured with a diminished weight of metal, it would manifestly be an important departure, and especially for naval purposes. A specimen piece of chain, 20 mm. diameter of link, which had stood a pull of 38 tons per square inch, was shown by the author.

Mr. Spencer, of Newcastle, said that patents had been taken out in England, for identically the same plan, in 1882. As a manufacturer of steel, he was asked, some two years ago, to undertake the carrying out of experiments thereon, and since that time they had made a considerable amount of steel chain of varying sizes, everything being, from a steel maker's point of view, perfectly successful. At the beginning they found that the smaller chain was comparatively easy to cast, the great difficulty usually being from the contraction; but when it came to the longer links, there they found very considerable difficulties indeed, because the steel, and especially mould steel, of which they cast it all, when run into the chilled mould, contracted immediately, very much more rapidly than they anticipated at the time, and the consequence was that there was a draw in the link.

But, by the improvements in the apparatus for the quick disengagement of the various pieces, they at last succeeded in making very considerable sized links on this plan, and he might say, now, that they would undertake to make a cable. He certainly had not encouraged their friend, Mr. Benman, the inventor (who was originally, he might say, a working chainsmith, and a very intelligent man), on account of the great cost, for when iron outfits for ships were being sold at about £11 per ton, they could not afford to make crucible steel chain at that price. One or two of the tests lately made would give the meeting some idea as to what was being done:

"A link was attached to two ordinary welded links of the best 2⅞ in. cable iron, without studs, and five sizes larger than the patent link, and sustained a strain of 78 tons 16 cwt. It was afterward tested to 96 tons, when one of the ordinary links parted at the weld, leaving the patent link in position slightly fractured, having sustained, without parting, an overproof strain of about 22 per cent. The elongation upon the patent link was ⅞ in., and on the ordinary also ⅝ in. Another link was also attached to two ordinary welded links of the best cable iron 2⅛ in. and four sizes larger than the patent link, studded and tested to the appropriate breaking strain, 82 tons 15 cwt. for studded cables, which it sustained, and was afterward tested as follows: 102, 104, 108, 112, 116, 120, and 124 tons, at which proof the welded link parted, leaving the patent link in position much fractured at a defective part. The elongation upon the patent link was 1⅜ in., and on the ordinary link 1¼ in., thus showing the patent sustained, without parting, about 50 per cent. above the required proof for studded chain cables for 1⅛ in.

"The next link tested was dealt with in the same way as the last one, as regards preparing for testing, and tested to the appropriate breaking strain, 82 tons 15 cwt., which it sustained, and was afterward tested as follows: 86, 92, 96, and 100 tons 16 cwt., when it was found, on examination, that one of the ordinary links had six fractures in it, and the patent link had none, thus showing the patent link to have sustained without parting (but showing a small fracture) an overproof strain of about 22 per cent. above the appropriate breaking strain. The elongation on this patent link was ¾ in., and on the ordinary link 1⅛ in. In another test the link was dealt with in the same way as No. 1, as regards preparing for testing, viz., two unstudded 2⅛ in. links attached, being five sizes larger than the patent link, and tested as follows: 96, 100, 105, 110, 115, 120, 125, 130, and 135 tons. At this proof the links were examined, and small fractures were found in the ordinary and also in the patent links. The links were so thoroughly rigid and locked together, owing to the enormous strain they had sustained (about 71 per cent. over the required proof), that it was impossible to ascertain any further injury to the specimen than that described above."

In every case the patent link had pulled asunder the other two, with considerable advantage, as a rule, in favor of the steel. There was no reason whatever why the steel, instead of being about 28-ton steel, should not go up to 30-ton steel, and even 35 or 40 tons. The chief point was to insure its soundness. He was quite satisfied that there were serious difficulties to be got over before a 50 or 60 fathom cable could be manufactured of crucible steel. He thought the line in which steel would be used in the manufacture of cables and other articles where very high strains were required, would be in the use of steel of a high grade of carbon—built up.

Mr. John Rogerson said that at the exhibition of 1867 a steel chain was shown that had been made at the Stanner Works, Wolsingham, of about twenty or twenty-five links, at the suggestion of Mr. Crawshay, of Messrs. Hawks, Crawshay & Sons. This was the result of a series of experiments that had been going on from several years during Mr. Attwood's time, possibly from the year 1865 or 1866. The chain was tested at their own works, and the cost was the only difficulty that Mr. Crawshay saw in its introduction for general purposes of cable chain. He was not at all certain that some were not supplied to the War Office for experiment, but he had no particulars, not having been aware that this paper was to be read, but had no doubt that he could, at some future meeting, supply a piece of the chain that was made and shown in 1867; they had the chain at present, and he would endeavor to show it at the Newcastle meeting.

Mr. Fox said that the firm he represented had been engaged in this work for some considerable time, and although they had encountered very serious difficulties on account of contraction, he thought he might safely say that they had overcome them. A ⅝ studded link chain had been tested to destruction; the test for that size of chain was 71½ tons, and it broke at 11 tons. They had also a 1⅜ chain, studded links. This was tested at Kirkcaldy's.

BLEACHING WITH CHLORINE GAS.

HERR GEORGE HERTEL has communicated to the *Faerberei Muster-Zeitung* some interesting results of experiments in bleaching cotton by means of chlorine gas, or rather hypochlorous acid gas. Several empty carboys were filled with scoured cotton; the mouth of each vessel was hermetically closed, and made to communicate with another empty carboy by means of a small pipe which could be closed up by a little stop-cock. The carboys filled with cotton were placed on a frame with their necks downward, while the empty bottles were placed below in an upright position. In the empty bottles was introduced chloride of lime, and afterward sulphuric acid, and then immediately covered, and the stop-cock opened communicating with the carboy above, in order to allow the gas to react on the cotton, when the bleaching was immediately effected. The author stated that no air should be allowed to enter the carboy containing the cotton at the same time with the gas, otherwise the bleaching reaction was diminished. With this dry bleaching process by gas, the proportions were as follows: 2 per cent. bleaching powder, ½ per cent. sulphuric acid to the weight of the cotton; while by the ordinary process (according to the author) 8 to 10 per cent. of chloride of lime is required. With the above proportions no injury was caused to the fiber, and a perfect bleach was obtained, which only required a washing and soaping to be complete; while it was found that by employing the gas obtained from 10 per cent. of bleaching powder the fiber was completely rotten. The author recommends the construction of an apparatus in which the gas could be pressed in by means of a pump, and thus made to react on the cotton. We rather think, however, that the best method would be to employ the well-known vacuum bleaching keirs, in which the vacuum would be first effected as is now done, but, instead of reacting with the bleaching liquor, to act with the bleaching gas liberated in carboys, or in larger stone or lead lined vessels. We do not apprehend any mechanical difficulty in the carrying out of the proposed bleaching process, since the apparatus already exists; but we apprehend one very great difficulty, and that is that, when treating large quantities of cotton, it would be very difficult, if not impossible, to have the gas penetrate all through the mass. It will also be remembered that chlorine was at first applied in the form of gas in the bleaching process, but that experience showed it to be best applied in the form now generally in vogue.

HISTORY OF THE ANILIN MANUFACTURING PROCESS.

M. BECHAMP, the inventor of the modern process for the manufacture of anilin, has made public some interesting facts concerning the way he came by his discovery. Zinin was the first chemist to show that anilin could be obtained by the reduction of nitro-benzine. He employed sulphydrate of ammonia as the reducing agent, a substance which yields only a very small product, and the reduction does not take place very easily by this means. Toward 1854 M. Bechamp was making investigation on gun cotton, which he at first believed to be a nitro product capable of reduction, like nitro-benzine, but, not succeeding in effecting the reduction, he concluded that pyroxylin was a nitrate of cellulose, a combination analogous to an ether in which cellulose acted as an alcohol. In treating gun cotton with protochloride of iron and a small amount of hydrochloric acid, he regenerated the cellulose; with the acetate of the protoxide of iron he also obtained the same result, the nitrogen of the nitric acid being in this case eliminated as ammonia. It was in conducting these investigations that the idea struck him of trying his method of reduction by means of the acetate of protochloride of iron on nitro-benzine, in which he was thoroughly successful, and which he simplified afterward by effecting the reduction by means of iron filings and acetic acid instead of the ready formed acetate. M. Bechamp's investigations were published in the *Annales de Chimie et de Physique* in 1854, in which the cost price of anilin is put down at 20 francs per kilo. In the discussion which followed in the sitting of the Societe Industrielle du Nord de la France, M. Faucher observed that he shared M. Bechamp's opinion as to gun cotton being a pentanitrate, while many chemists, especially in Germany, consider the same as a trinitrate of cellulose.

THE MAKING OF RUBBER STAMPS.

THE wording of the desired rubber stamp having been correctly set up in ordinary type, the same is locked up and placed upon a level support. Around it is put an iron frame, which will determine the shape and size of the matrix.

By means of a soft brush, the type as well as all surrounding parts that are to be covered by the plaster of Paris are well oiled.

For the purpose of making the cast, finely ground fresh plaster of Paris is needed; if of long standing, the same will lose its desirable properties. This plaster of Paris, of which a sufficient quantity should at one time be mixed to the consistency of pap, using clear water, is poured over the frame containing the type in a thin layer, so as to barely cover it. With a stout brush the mixture is driven into all spaces and interstices, until all details are thoroughly covered. After this the remaining pap of plaster of Paris is added until the frame is full to overflowing. The surface is smoothed down, after the plaster has settled somewhat, and in a short while the matrix in the frame may be removed from the type.

After this it becomes necessary to bake the matrix in an oven for a period of from four to six hours. When thoroughly baked, the matrix should be well brushed with a thin solution of sheilac to impart a smooth surface, and, at the same time, greater strength.

The matrix at this stage represents a yellowish-white block, in which the lettering appears indented, but in proper place. The indentation corresponds to the height of the letter upon the piece of type or the marks upon a cut, while the remaining parts should be perfectly smooth and free from holes. This matrix, obtained by a coating from the type or cut, will serve as the mould for the final rubber stamp.

Pieces of caoutchouc are cut to the required size and laid upon the matrix. If pressure is now exerted, the soft mass will adjust itself to fill all the spaces and reproduce the mould invertedly. Indentations become raised matter, and the whole will show as did primarily the type.

But as the caoutchouc has a tendency to return to its previous shape, it becomes necessary to apply the process called vulcanizing. The object is to impart hardness to the rubber, and to prevent its losing the form into which it has been pressed.

To accomplish this, the caoutchouc must be heated

to a temperature of from 120° to 130° C. As the substance is ordinarily softened by heat, it is necessary to take some means to prevent it from sticking to the mould. For the purpose soapstone will answer, and the mould, as well as the piece of caoutchouc, should be well brushed or dusted with this substance.

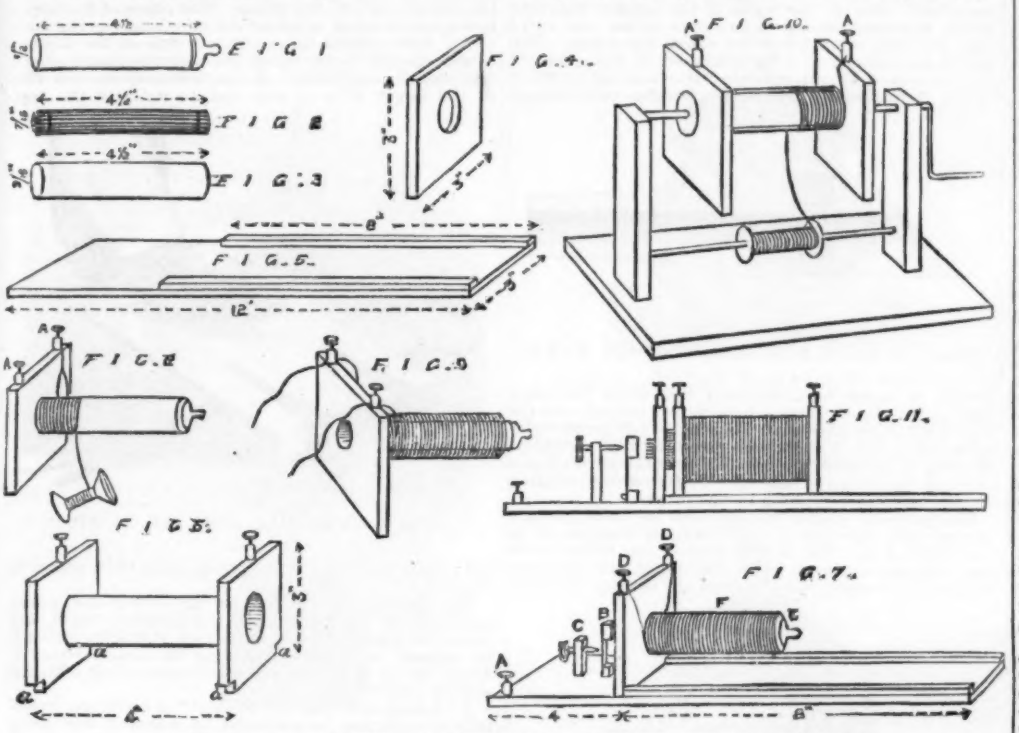
The duration of the heating varies with the thickness of the rubber sheet. As a general thing, from 20 to 30 minutes ought to be sufficient. It may be mentioned here that special apparatus has been constructed for pressing and vulcanizing. The proper vulcanization is of the greatest importance in determining the durability of the stamp.

All that remains to complete the stamps is the mounting of the rubber plate upon a suitable base or handle. This is best done either with zinc or with a solution of caoutchouc in benzine. The surface of the handle, as well as the back part of the stamps, having been covered with such a solution and well pressed together, after drying the entire stamp will be ready for use.—*Amer. Lith. and Printer.*

HOW TO MAKE A MEDICAL COIL WITH PRIMARY AND SECONDARY CIRCUITS AND REGULATORS TO BOTH.

By S. R. BOTTONE.

1. PROCURE a well seasoned board of walnut about 21½ in. in length, 3 in. wide, and ⅜ in. thick. From this cut one length 12 in. long for the base board (Fig. 5) and three pieces 3 in. square (like Fig. 4) for the coil heads; when cut, a fillet 8 in. long must be nailed or screwed on the two sides of the base board (as shown in Fig. 5); these fillets should be ¼ in. square section. Corresponding square nicks must be cut of *two* of the square heads (as shown at *a*, *a*, *a*, *a*, Fig. 6). All the woodwork when thus squared and finished should be soaked for a quarter of an hour in melted paraffin wax, and then rubbed dry while still warm.



HOW TO MAKE A MEDICAL ELECTRICAL COIL.

2. Procure a thin brass tube (known in the trade as "triblet tubing") about ⅛ in. diameter, 4½ in. long; turn up a short plug and button to fit one end of this tube and serve as a handle (see Fig. 1, *a*). This may be fastened to the tube by driving in three fine brass brads, and filing off the heads flush with the tube.

3. Now cut up about 100 lengths of straight iron wire (best soft annealed) No. 22 gauge, say, about 4½ in. in length; fill the brass tube with them as tight as you can fit them; cut them all to the same length (they must protrude a little beyond the tube). Now draw out about a couple of inches of the iron bundle and wrap it tightly round with twine, leaving about ½ in. free. Draw more out, and continue wrapping until you have wrapped to within ½ in. at each end of the bundle. Tie the string, and withdraw the bundle from the brass tube. Melt a little solder in a ladle, dip the ends of the iron bundle into soldering fluid (zinc dissolved in hydrochloric acid), and then at once into the melted solder. Allow the bundle to cool; file off the superfluous solder, so that the bundle will just enter freely into the tube. It should appear like Fig. 2 when the string has been removed.

4. The next operation is to make a good stout paper tube, also about 4½ in. in length, into which the brass tube (Fig. 1) can slide easily. To make this, put a few turns of soaped writing paper round the tube No. 1, then roll and glue seven turns of good stout brown paper, 4½ in. in length, round this writing paper, or else it will be difficult to draw out the tube. This paper tube (Fig. 3) must be allowed to dry thoroughly while still on the brass tube (Fig. 1). When *quite* dry, it must be slipped off, the writing paper lining drawn out, and then it must be soaked for a few minutes in melted paraffin wax.

5. The iron bundle should also be allowed to stand in melted paraffin wax for some time, and then stood up to drain in a warm place. This will prevent rusting. When quite cold, all superfluous paraffin having been removed, a strip of brown paper, ½ in. wide, is rolled round one extremity of the iron bundle, until it is of such a diameter as to fit tightly into the paper tube, Fig. 3. This paper strip must be cut off at this point and glued tightly round the end of the iron bundle. The brass tube (Fig. 1) is then slipped over the iron bundle until it just reaches the little paper collar just made. The brass tube and bundle together are pushed, button end first, into the paper tube, Fig. 3; and when the paper collar around the iron bundle is just about to enter the paper tube, it is to be well served with hot glue and forced into the tube. The whole must now be allowed to dry and set thoroughly.

6. Taking one of the 3 in. heads (the one which has not any nicks in the sides), we bore a central hole with a brace and center bit, just large enough for the paper tube (Fig. 3), with its iron core, to fit tightly (see Fig. 4). Putting a little thin good hot glue round the free extremity (the end opposite that at which the brass enters), we push it into the hole in the square head, until it projects about ⅛ in. on the other side. This must be allowed to dry thoroughly before proceeding to the next operation.

7. We may now proceed to wind the primary coil. To this end, we take about ½ lb. of No. 24 silk-covered copper wire, and wind it round the tube, as shown at Fig. 8, from end to end, in continuous layers, taking care to put a sheet of paraffined paper between each layer, and also to baste each layer with melted paraffin wax before winding on another. About four layers will thus be got on, and an even number of layers must be aimed at, so as to get the two ends of the wire at the same extremity, so as to be able to fasten them *under* the binding screws, A A (Fig. 8). To effect this, before screwing down the said screws, the ends of the copper wire are stripped of their covering and wound once round the screw of the binder. Free ends of wire, at least 6 in. in length, must be left for attachments, etc. This is shown at Fig. 9.

8. This primary coil, with its iron core, sliding brass tube regulator, etc., may now be fastened to the base board by means of two screws from underneath, as shown at Fig. 7, at 4 in. from one end, and therefore 8 in. from the other. One of the free ends of the primary wire is brought to one of the binding screws, A, while the other connects to the clapper, B. A short piece of wire connects the platinum screw pillar, C, to the other binding screw, which is not visible, as it is behind the platinum pillar. At this point it will be well to try the working of the primary coil. For this purpose, couple up the two binding screws on the base board with a good bichromate cell. Connect the two binding screws, D D (Fig. 7), with the two brass handles intended for use. Screw up the platinum screw, C, the clapper, B, begins to vibrate. Now hold the handles in your hand. As long as the brass tube, E, is entirely over the iron core, little or no sensation is perceptible. If an assistant pull out the tube, little by little, the current will be found to increase in strength until the regulator tube is quite out.

9. The secondary coil now demands our attention. A paper tube, precisely similar to Fig. 3, but of such a size as to slide *easily* over the primary coil, E (Fig. 7), is prepared, and paraffined. This must be cut exactly the length of the coil, F, leaving the knob, E, projecting. The two square pieces of board in which the nicks were cut (Fig. 6) must then have central holes cut in them to take this paper tube, and then glued, one at each end of the said tube, as shown at Fig. 6. Two small binding screws are then to be inserted in the center of the upper edge of each square. A bung is now placed in each end of the tube, and a ¼ in. iron rod pushed through both, to serve as an axle. This is then mounted on two standards, as shown at Fig. 10; and beginning by attaching one end of the uncovered wire to the binding screw, A, about ½ lb. No. 36 silk-covered copper wire is now carefully coiled on, being most diligent in avoiding kinks, breaks, or flaws of every description. Each layer must be paraffined and separated from its neighbor by paraffined paper. When the quantum of wire has been laid on, the finishing end is connected to the binding screw, A^1, Fig. 10. The last coil should be covered with paraffined paper, and finally covered with a jacket of good silk velvet. The secondary coil is then complete, and may be slid in its place over the primary, coil (see Fig. 11). When it is quite over the primary, the secondary current will be at its strongest, if the metal tube regulator is drawn out; it will be weaker as the metal tube regulator is more and more inserted; or may be even more delicately regulated by sliding the secondary coil itself more or less over the primary. The secondary coil, while the primary is being excited with a freshly made pint bichromate, will give a ½ in. spark when the regulator is out and the secondary coil right over the primary. This will pass easily through a dozen persons.—*Eng. Mechanic.*

[ELECTRICAL REVIEW.]

BOURSEUL'S TELEPHONE OF 1854.

IN 1845, a wise and modest young man, reared in peaceful studies, became a soldier of the army of Africa; but being devoted to science, and gifted with one of those privileged intellects which permitted him to reach its highest regions, he did not despair. "I have no longer my professor," said he, "but I have yet my books; these shall be my friends, my guides, my consolers."

In 1849, at length, the young Charles Bourseul, son of an army officer, and himself a soldier in the 43d Line, gave his comrades of the garrison of Algiers a course of mathematics which attracted the attention and friendly interest of the Governor-General of Algiers. No one had recommended the simple soldier to the General, he had recommended himself; and the General, recognizing his merit, had generously held out a protecting and friendly hand. There is in that simple fact a touching eulogy of the soldier and the General.

To-day, freed from military service, Mr. Charles Bourseul dwells in Paris, and it is he who is the author of the curious article which you are about to read. We wish him all the success that he himself expects, and we shall be happy to see him attach his name to the marvelous discovery of the transmission of speech by electricity. Electricity has performed so many miracles, why not that (in despite of the Academy, where it is treated as a folly, or, when one wishes to be polite, as Utopian) which has not yet been attempted?—a view which is encouraging, it is necessary to avow, for the inventors, for those sublime initiators without whom the Academy would be but a collection of fossils. Let us say it once more, to sustain the ardor of genius in the search for the unknown: There is nothing to expect, unless an insolent sneer, from these votaries of science. Fulton and enough of others learned so to their cost, but if you speak to-day to an Academician of steam and the telegraph, he will tell you the thing was very simple, and that if the Academy had wished to take the trouble, the discovery would have been made very much sooner. Ah, well, most wise doctors, here is a problem. Read the note of Mr. Charles Bourseul:

"It is known that the principle on which telegraphy is founded is the following:

"An electric current, passing over a wire, comes to a piece of soft iron, which it converts into a magnet. Whenever the current is absent, the magnet has ceased to exist.

"That magnet, which takes the name of electro-magnet, can, then, attract and set free, in turn, a movable plate, which, by its coming and going, produces the signals employed in telegraphy.

"Sometimes one uses that movement directly, and makes it produce points and dashes on a band, which is unrolled by a clock movement. The customary signals are then formed by combinations of these dashes and points. Such is American telegraphy, which bears the name of Morse, its inventor.

"One also converts that coming and going movement into a rotary movement. Thus are derived the dial-telegraph of the railroads and the state telegraph, which latter, by means of two wires and two needle indicators, reproduces all the signals of aerial telegraphy, as heretofore used.

"Let us imagine now, placed on a horizontal movable circle, the letters, figures, punctuation marks, etc. One can see that the principle explained will serve to enable him to choose at a distance such and such a character, to determine its movement, and, consequently, to print it on a page placed for the purpose. Such is the printing telegraph.

"A further step has been made. By means of the same principle, and by a mechanism sufficiently complex, we have attained a result which, at first glance, seems a prodigy. Writing itself is reproduced at a distance, and not only writing, but a stroke, a curve, in such manner that, being in Paris, you are able to design a profile by ordinary means, and the same profile is designed at the same time at Frankfort.

"The efforts made in these directions have succeeded; the apparatus has figured in the London expositions. There is, however, something lacking to perfect the details.

"It will seem impossible to go further in the direction of the marvelous. Let us try, however, to take some further steps. I have asked myself, for example, if speech itself cannot be transmitted by electricity; in a word, if one can speak at Vienna and make himself heard at Paris.

"The thing is practicable; and this is how it can be done:

"Sounds, every one knows, are formed by vibrations, and carried to the ear by the same vibrations reproduced by the medium which intervenes.

"But the intensity of these vibrations diminishes very rapidly with distance, in such a way that there are, even to speaking trumpets, horns, and acoustic cornets, very narrow limits, which cannot be passed. I imagine that one is speaking near a movable plate, so flexible that it will not miss any of the vibrations produced by the voice; that this plate establishes or interrupts successively communication with an electric pile. You will be able to have at a distance another plate, which will make at the same time exactly the same vibrations.

"It is true that the intensity of the sounds will be variable at the point of departure where the plate vibrates from the voice, and constant at the point of arrival, where it vibrates from the electricity, but it is shown that it cannot alter the sound.

"It is evident, also, that the sounds will be reproduced at the same height of the gamut.

"The present state of acoustic science does not permit one to say, *a priori*, whether the articulate syllables of the human voice can be reproduced. The manner of producing these syllables has not been sufficiently studied. It has been remarked, it is true, that

some are pronounced from the teeth, others from the lips; but that is all.

"However that may be, it is necessary to suppose that the syllables are exactly reproduced (to the ear) by nothing but the vibrations of the intervening medium. Reproduce, then, those vibrations, and you will also reproduce exactly the syllables.

"In any case, it is impossible to demonstrate, in the present state of science, the impossibility of transmitting sound by electricity. All the probabilities, on the contrary, point the other way.

"When it was first proposed to transmit dispatches by electricity, a man in the high ranks of science treated the idea as extravagantly Utopian, and yet we communicate directly between London and Vienna by a simple wire. That is not possible, they say, and it is done.

"It goes without saying that applications without number, and of the highest importance, will arise immediately from this principle of transmitting speech by electricity.

"Not to be deaf and dumb, whoever is that cannot use this means of transmission, which will need no apparatus; an electric pile, two vibrating plates, and a wire will suffice.

"In a multitude of cases, in vast industrial establishments, for example, one will be able by this means to transmit at a distance such an order or piece of information; whereas one will not do so by electricity so long as an apparatus such as is used in telegraphy, and special training, would be required to accomplish the object better by letter.

"However it may be, it is certain that, in a future more or less far off, speech will be transmitted for long distances by electricity. I have begun experiments; they are delicate, and require time and patience; but, as far as I have gone, the results promise a favorable issue. CHARLES BOURSEUL.

"Paris, August 18, 1854."

AN INEXPENSIVE AIR PUMP.

By GEO. M. HOPKINS.

I.

A BRASS air pump gleaming with polished and lacquered surfaces, mounted on the conventional mahogany base, and furnished with accessories for convenient experimentation, is desirable and useful, besides being ornamental; but how many of those interested in the study of pneumatics have free access to such a machine, or, indeed, any other apparatus which will enable them to investigate practically and individually the interesting phenomena of the air and gases? It may be safely said that the number is comparatively small. The engraving illustrates an efficient air pump for both exhaustion and compression, which may be made from materials costing one dollar and fifty cents, and with the expenditure of not more than two or three hours' labor.

With this pump, the entire range of ordinary vacuum and plenum experiments may readily be performed by the aid of a few well known and inexpensive articles, such as lamp chimneys, fish globes, a tumbler or so, and pieces of sheet rubber, bladder, etc.

In the present article, only the pump will be described, the experiments and accessory apparatus being reserved for a future article.

Fig. 1 illustrates the manner of using the pump. Figs. 2 to 5, inclusive, are sectional views of the pump and its valves. Fig. 6 shows a form of valve for the compression pump, and Fig. 7 shows the application of a foot pedal to the pump.

The materials required are as follows: A piece of so called pure rubber tubing 1¾ inches external diameter,

FIG. 1.—TESTING SIMPLE AIR PUMP.

1 inch internal diameter, and 9 inches long; a piece of pure rubber tubing 1 inch external diameter, ⅝ inch internal diameter, and 5 inches long; a piece of heavy pure rubber tubing ⅝ inch external diameter, and 4 feet long; two wooden valve casings (shown in Fig. 3); a strip of the best oiled silk, ⅜ inch wide and 8 or 10 inches long; and some stout thread.

The piece of 1 inch rubber tube is cut diagonally at an angle of about 30°, so as to divide it into two similar pieces. The wooden valve casing is pierced longitudinally with a one-sixteenth inch hole and transversely with a hole ⅛ inch square, and thoroughly shellacked or soaked in melted paraffine to render it impervious to air. The longitudinal hole is cleared out, and the walls of the square transverse hole are smoothed. One of the walls of the square hole into which the one-sixteenth hole enters forms one valve seat, and the other forms the other valve seat. The valves each consist of two thicknesses of the oiled silk strip stretched loosely over the valve seat, and secured by the thread wound around the wooden valve casing.

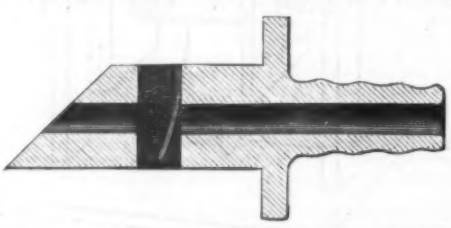


FIG. 6.—VALVE FOR COMPRESSION PUMP.

It will, of course, be understood that when the valve casings are placed in the 1 inch rubber tubing, and the 1 inch tubes are placed in the ends of the larger tube, as shown in Fig. 2, the valves must both be capable of opening in the same direction, so that the air may pass through the pump as indicated by the arrow entering by one valve and escaping by the other.

The pieces of rubber tube inclose the valve casings, so that each valve has a little air-tight chamber of its own to work in. The beveled ends of the rubber tube are arranged as shown in the engraving, and the inner ends of the wooden valve casings are beveled to correspond, so that when the large rubber tube is placed on the floor and pressed by the foot, there will be very little air space left in the pump. The four foot rubber tube is atached to one end of the pump for vacuum experiments, and to the opposite end for plenum experiments. To avoid any possibility of the sticking of the valves, the valve seats are rubbed over with a very soft lead pencil, thus imparting to them a slight coating of plumbago, to which the oiled silk will not adhere. As an elastic rubber pump barrel, of the kind described, requires considerable pressure of the foot to insure the successful operation of the pump, it is advisable to construct a treadle like that shown in Fig. 7. It consists of two short boards hinged together, the lower one having a shallow groove for the reception of

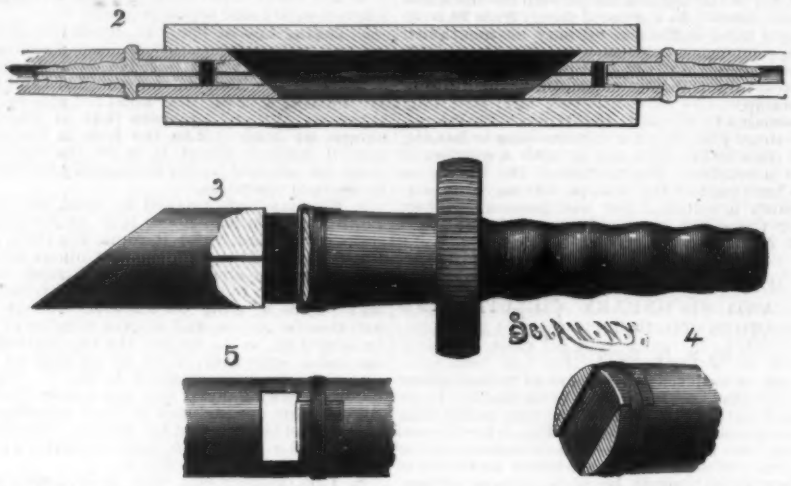


FIG. 2.—LONGITUDINAL SECTION OF SIMPLE AIR PUMP. FIG. 3.—VALVE CASING PARTLY IN SECTION. FIG. 4.—TRANSVERSE SECTION SHOWING VALVE IN PERSPECTIVE. FIG. 5.—PLAN VIEW OF VALVE.

the middle part of the pump. The edges of the upper board are beveled at about the same angle as the ends of 1¾ inch rubber tube. The width of the hinged boards should be somewhat less than the length of the chamber in the pump. A mark is made on the side of the larger tube at one end to indicate the top,

FIG. 7.—TREADLE FOR AIR PUMP.

the proper position for the pump being that shown in Fig. 2.

The pressure of the foot on the side of the pump barrel expels the air through the discharge valve, and when the barrel is released, its own elasticity causes it to expand, and while regaining its normal shape it draws the air from any vessel communicating with the suction valve.

A vacuum sufficient for most of the ordinary experimental work may be produced by means of this pump in a short time. A gauge may be improvised by attaching the suction pipe to a piece of barometer tube about 30 inches long, and dipping the end of the tube in mercury, using a yard measure as a scale, as shown in Fig. 1. The pump will be found to compare favorably with piston pumps.

When it is desired to construct a pump of this kind for compressing air or for a low vacuum, the elastic tube forming the pump barrel may be larger and thinner, and the hole through the wooden valve casing may be made larger, as shown in Fig. 6, and the oiled silk valve may be replaced by a simple rubber flap valve, held in place by a single tack.

II.

A great deal of experimental and practical work may be done with this simple air pump. The apparatus need-

FIG. 8.—HAND GLASS.

ed for the vacuum experiments cost less than the pump. They consist of a fish globe 6 in. in diameter, a disk of thick, soft rubber large enough to cover the fish globe, a plain disk of wood as large as the rubber, two 3 in. pieces of five-sixteenth inch brass tubing, a lamp chimney with a flange on the lower end, a cork fitting

FIG. 9.—RUBBER FORCED INWARD BY AIR PRESSURE. FIG. 11.—DISRUPTIVE FORCE OF AIR.

the small end of the chimney, a thin piece of bladder, a thin piece of very elastic rubber, a small bell, a tumbler, a small rubber balloon, some sealing wax, some stout thread, and a piece of small wire.

The lamp chimney needs no other preparation for use than the insertion of one of the five-sixteenth inch

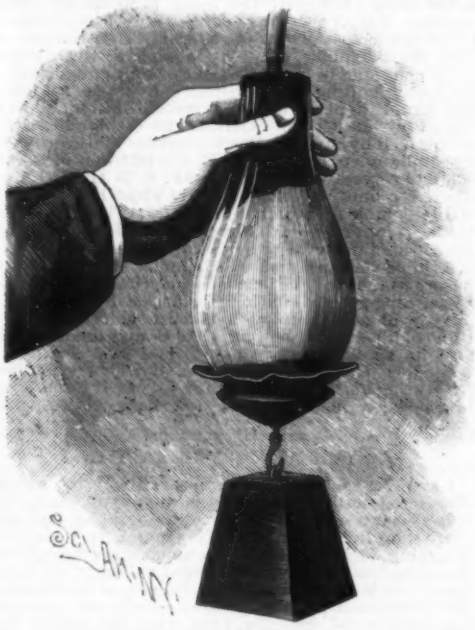


FIG. 10.—WEIGHT LIFTED BY AIR PRESSURE.

tubes in the center of the cork and the thorough sealing of the cork with its tube in the smaller end of the chimney.

A very striking and instructive experiment consists in exhausting the air from the chimney by applying the suction tube of the pump to the tube at the closed end of the chimney, while the palm of the hand is applied to the large open end of the chimney. As the air is exhausted from beneath the hand, the pressure of the atmosphere exerted on the hand drives the palm down into the chimney, as shown in Fig. 8, and as the

FIG. 12.—DILATION OF A BALLOON IN A VACUUM.

exhaustion proceeds, the pressure becomes painful and difficult to endure.

It is easy under such circumstances to realize that the atmosphere has a very appreciable weight.

The same fact may be illustrated by tying over the open end of the chimney a thin piece of elastic rubber, then exhausting the air from the chimney, allowing the external air to press the rubber down into the chimney, as shown in Fig. 9.

In Fig. 10 is illustrated a similar experiment, in which the inwardly pressed diaphragm is made to raise a weight. A piece of rubber cloth is tied over the open

FIG. 13.—DESTRUCTION OF LIFE BY REMOVAL OF AIR.

end of the chimney and a hook is fastened to its center by sewing. The cloth is heavily coated with rubber cement around the sewing of the hook. A weight is placed on the hook, and the air is exhausted as before.

FIG. 14.—WATER BOILING IN VACUO.

The upward pressure of the atmosphere raises the weight. This experiment illustrates the action of a form of vacuum brake now extensively in use; the weight representing the brake.

FIG. 15.—BELL IN VACUO.

This disruptive power of atmospheric pressure is illustrated by the rupturing of a thin piece of bladder tied over the open end of the chimney, as shown in Fig. 11. When the air is exhausted from the chimney, the bladder, if thin enough, will burst with a loud report. If the bladder will not readily burst, the rupture may be started by puncturing it with the point of a knife.

The fish globe forms the receiver of the air pump. It is closed by the soft rubber disk, which is supported by the wooden disk, the rubber being secured to the wood by four common screws passing through the rubber into the wood, about midway between the center and circumference of the rubber. Both the board and the rubber are apertured to receive a five-sixteenth tube, which is provided with a fixed collar at the top of the wood and with a screw collar at the outer face

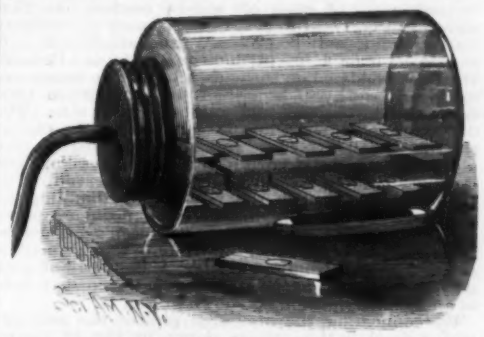


FIG. 16.—WITHDRAWING AIR FROM MICROSCOPE SLIDES.

of the rubber disk. The screw collar is turned down upon the rubber, clamping it to the wood, and at the same time making an air-tight joint around the tube.

The suction tube of the pump is applied to the small brass tube, and the soft rubber disk is pressed down upon the mouth of the globe, when the operation of producing a vacuum is begun. After a few strokes of the pump, the cover will be retained on the globe by atmospheric pressure, and will need no further holding by the hand.

The expansibility of air is shown by inclosing a small quantity of it at atmospheric pressure in an elastic rubber balloon,* and placing the balloon in the receiver, then removing the atmospheric pressure from the exterior of the balloon by exhausting the receiver. The air in the balloon will expand, distending it, as shown in Fig. 12.

The inability of rarefied air to support life is shown by the experiment illustrated by Fig. 13. A mouse in the receiver soon dies when the air is exhausted.

The fact that water boils at a temperature below 212° when the atmospheric pressure is removed, is exhibited by placing a tumbler of hot, but not boiling, water in the receiver, as shown in Fig. 14, then exhausting the air from the receiver.

The bell suspended in the receiver by a light elastic rubber band stretched across a wire fork, whose shank is inserted in the tube of the receiver cover (as shown in Fig. 15), may be distinctly heard when rung in the receiver before exhaustion; but after exhausting the receiver, the bell will be heard feebly, if at all, thus showing that the air when rarefied is a poor sound conductor.

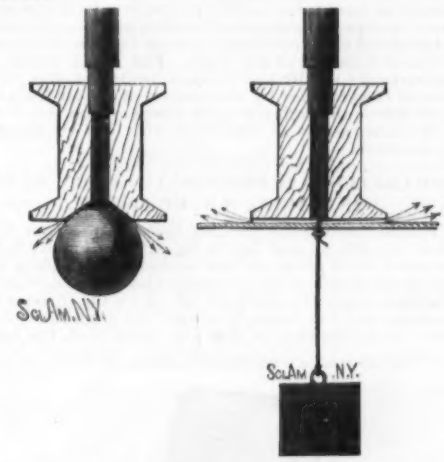


FIG. 19.—BALL PARADOX. FIG. 18.—CARD EXPERIMENT.

A device for use in connection with the simple air pump for desiccating and for removing air from microscope mounts is shown in Fig. 16. It consists of an ordinary fruit jar having a short tube soldered in its cover, which is adapted to receive the suction tube

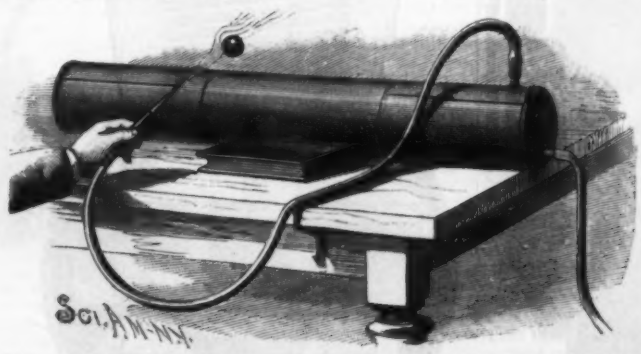


FIG. 17.—COMPRESSED AIR RESERVOIR AND BALL EXPERIMENT.

of the air pump. The objects to be treated are placed in the jar, the cover put on and made tight, and the suction pipe of the pump is applied.

*The small inflatable balloons applied to the toy squawkers, and which may be bought in any toy store for three cents, answer perfectly for this experiment.

These are mostly well-known vacuum experiments, adapted to the simplified apparatus. There are, of course, many others that may be performed with equal facility by means of this air pump.

With the pump arranged for compression, a large number of experiments of a different character may be performed. A reservoir will be needed, like that shown in Fig. 17. It consists of a piece of ordinary leader, such as may be procured from any tinman. It should be 3 or 4 in. in diameter and 3 or 4 ft. long. Heads are soldered on the ends, and all the seams are made air tight by soldering. A five-sixteenth in. tube is inserted in one end, and another in the side. The discharge end of the pump is connected with one of the tubes of the reservoir, and a rubber tube, having at one end a one-sixteenth inch nozzle of metal or glass is connected with the other tube of the reservoir. The air may be confined in the reservoir by doubling the discharge tube or applying to it an ordinary pinch cock. When sufficient pressure has been generated in the reservoir by operating the pump, the air may be allowed to issue from the nozzle. A light ball of cork may be supported in the air jet while the nozzle is held in an inclined position, as shown in Fig. 17.

By connecting the discharge pipe of the reservoir with a spool, in the manner shown in Fig. 18, the familiar experiment of sustaining a card, together with an attached weight, by blowing down on the card may be performed. A pin passing through the card into the central aperture of the spool prevents the card from slipping.

Fig. 19 shows a simple way of exhibiting the ball paradox. A spool, concaved at one end around the central hole, is connected at the opposite end with the air reservoir. The ball is held in the concavity of the spool by blowing forcibly outward against the ball.*

FIG. 20.—ATOMIZING PETROLEUM BURNER.

In Fig. 20 is shown an atomizer, which may be used in connection with the reservoir and air compressor for atomizing liquids for various purposes. In the present case it is represented as an atomizing petroleum burner. A burner of this kind yields a very intense heat, and produces a flame 2 or 3 ft. long. The oil is drawn up the vertical tube by the vacuum formed in the outer tube of the atomizer by the passage of the air from the inner nozzle through the outer nozzle. The outer end of the inner nozzle is connected with the compressed air reservoir.

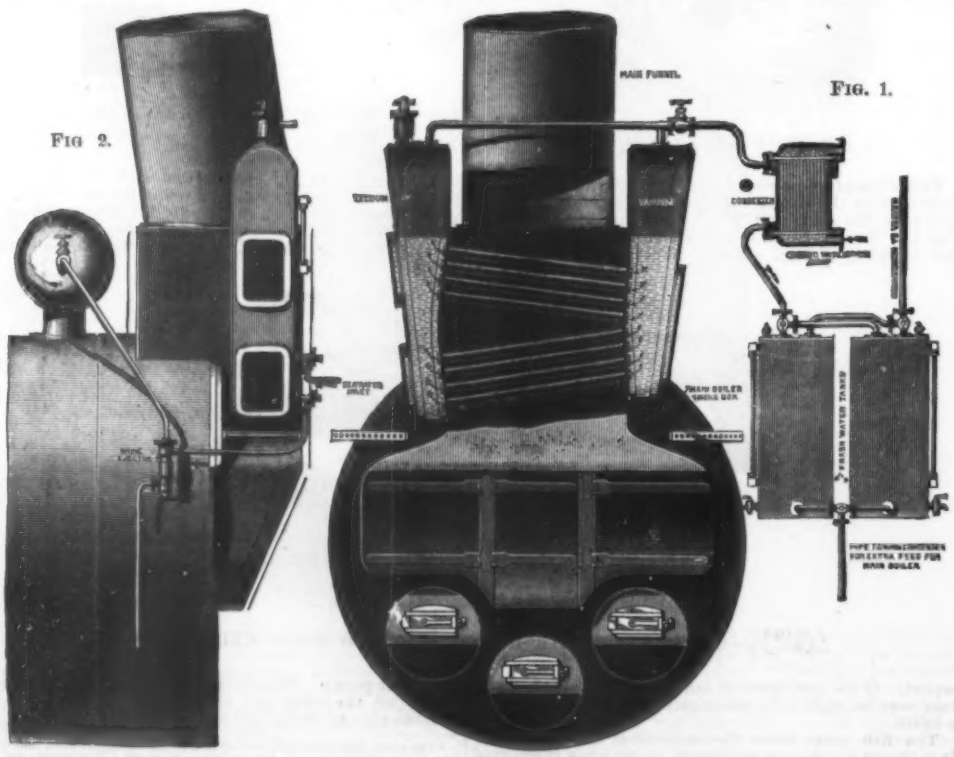
* The ball paradox is explained in SUPPLEMENT, Nos. 37, 47, 51.

APPARATUS FOR EVAPORATING SEA WATER IN VACUO, S.S. BENTINCK.

THE increase in the working pressure of steam from 90 lb. to 160 lb. has led to the failure of many boiler furnaces, both plain and corrugated. On inquiry into the cause of failure many theories have been advanced. In some cases the presence of oil on the furnace has been deemed the cause, in others the accumulation of scale on the furnace, or that the density of the water has been too great. Now, whatever may be the case, it is clear that as long as the furnace remains in the same condition as when the hydraulic test was applied, it will not collapse when subject to the working pressure, nor is there a recorded instance of a furnace collapsing at sea within a few days after the ship left port on her first voyage. It may therefore be fairly assumed that when the Board of Trade formula has been used for the strength of the plate, the absence of scale is the true cause of the furnace remaining perfect, and, on the other hand, that the presence of scale is the chief cause of failure. Bearing on this subject, we illustrate a new patent arrangement for changing salt or impure water into the purest distilled water for supplying the extra feed required in marine boilers, and also for other purposes. The plan explains itself, but for non-professional readers a few explanatory remarks may be desirable. The principle of the invention is the evaporation of water *in vacuo*, or, in other words, boiling away the water at a lower temperature than 212 deg. With the arrangement as shown, water is changed, by the waste heat passing up the funnel at a temperature of from 600 to 700 deg., into vapor at a temperature of between 90 and 212 deg., depending, of course, on the vacuum obtained in the condenser used for the purpose of lowering the pressure. After the vapor is given off it passes into a separate condenser of the usual type, but under vacuum instead of pressure. An arrangement of valves and pipes is provided by which the distilled water may be conveyed to water tanks and drawn off for drinking, supplying cattle, or for any other purpose required on board ship. When supplying the extra feed required for the boilers, the vapor is conveyed into the main engine condenser. In the process of evaporation the salt and other impurities are left in the evaporator, and consequently an ejector is used for ejecting these impurities. In combination with this arrangement, the water after condensation can be aerated and become as good as spring water. Doors are fitted in the uptake for sweeping the outside of the evaporator tubes. The plan shows an apparatus capable of supplying 2,000 gallons of pure water per twenty-four hours. One good feature in this invention is that an almost unlimited supply of fresh water may be produced on board ship by using the waste heat passing up the funnel—in other words, without any additional cost or the usual loss of fuel by taking live steam from the main boiler. The arrangement has been applied to the screw steamer Bentinck, and the water produced by it is of the purest quality and tasteless. Fig. 1 is a front view, partly in section, and Fig. 2 is a side view the covers in the tube chambers being removed. As the lime is thrown down in the tubes at a very low temperature, the tubes are kept clean without any trouble.—*The Engineer*.

FIG. 2.

FIG. 1.



APPARATUS FOR EVAPORATING SEA WATER IN VACUO, S.S. BENTINCK.

THE NEW ELEMENT, GERMANIUM.*

SOME months ago Dr. Clemens Winkler announced the discovery of a new element which he named germanium, a preliminary account of which has already appeared in these columns. Dr. Winkler has since been able to make a more systematic examination of the subject, and he now describes in detail the preparation and properties of the new element and also of a number of its compounds. The view he first held, that germanium occupied a position in the periodic system intermediate between antimony and bismuth, he now shows to be untenable, there being now no doubt that it is the *ekasilicium* of Mendelejeff, prophesied fifteen years ago. This latter view was, in fact, expressed by Richter, Mendelejeff, and Lothar Meyer shortly after the discovery of germanium.

The new element occurs, as previously stated, in the recently discovered mineral argyrodite. Its isolation is, however, difficult, especially from the presence of arsenic and antimony in minerals which accompany argyrodite. The formula assigned to the latter mineral is $3Ag_2S,GeS_2$.

The following is the best method for separating the germanium. The finely powdered mineral is intimately mixed with an equal weight of soda and sulphur, and the whole submitted to the action of a moderate red heat in a Hessian crucible. The product is powdered while still warm, and repeatedly boiled with water. The aqueous extract is slightly acidulated with sulphuric acid, and the precipitated sulphides of arsenic and antimony allowed to settle. On then adding a considerable excess of hydrochloric acid, the germanium sulphide is thrown down as a white voluminous precipitate. This is gently roasted, then heated with concentrated nitric acid, and finally ignited. The germanium oxide obtained may be reduced by ignition in hydrogen.

Germanium has a melting point apparently somewhat lower than that of silver—that is, about 900°—and at a temperature a little higher than this it appears to volatilize. It crystallizes in octahedra, is extremely brittle, has a perfect metallic luster and a grayish-white color; its specific gravity is 5·469 at 20·4°. It is insoluble in hydrochloric acid, is readily dissolved by aqua regia, is converted into a white oxide by nitric acid, and into a soluble sulphate by concentrated sulphuric acid.

Determinations of the atomic weight of germanium were made by estimating the percentage of chlorine in the chloride, $GeCl_4$, and the number 72·32 was obtained as the mean of four experiments, this number agreeing closely with the atomic weight of Mendelejeff's ekasilicium.

The specific heat of the new element has been determined by Nilson and Pettersson, at temperatures between 100° and 440°, with the following results:

	1	2	3	4
Specific heat...	0·0737	0·0772	0·0768	0·0757
Atomic heat...	5·33	5·58	5·55	5·47

Compounds of Germanium.—Oxides: There are two oxides of germanium, namely, GeO and GeO_2. The former is obtained in the hydrated condition by heating the corresponding chloride ($GeCl_2$) with sodium carbonate solution; on heating the precipitate in a current of carbonic anhydride, the water is expelled and the grayish-black oxide, GeO, remains. The higher oxide is obtained by burning germanium in oxygen, or by decomposing the chloride, $GeCl_4$, by water; it forms a dense white powder slightly soluble in water, possesses both basic and acid properties, the latter being, however, the more pronounced. *Sulphides:* Two of these are likewise known, corresponding to the oxides. The lower sulphide, GeS, is obtained from the disulphide, either by heating it with an excess of germanium in a current of carbonic anhydride, or by gently igniting it in a current of hydrogen; it forms beautiful thin plates of almost metallic luster and having a gray-black color. Germanium disulphide, GeS_2, is obtained by precipitating a solution of the dioxide by sulphureted hydrogen with the addition of a considerable excess of a mineral acid; it is then thrown down as a bulky white precipitate which is very appreciably soluble in water. *Chlorides:* The dichloride, $GeCl_2$, is formed when hydrochloric acid gas is passed over heated pulverulent germanium or its sulphide; it is a thin colorless liquid, which fumes strongly on exposure to the air. The tetrachloride, $GeCl_4$, is produced by burning germanium in chlorine, or by distilling a mixture of germanium with mercuric chloride; it is a thin colorless liquid boiling at 86° C. and fuming in the air; its specific gravity at 18° is 1·887. *Iodide:* A tetriodide, GeI_4, only is known, and is best obtained by heating germanium in iodine vapor; it forms a yellow powder, melts at 144°, and boils between 350° and 400°.

* Clemens Winkler, *Journal f. prakt. Chemie*, 1886, pp. 177-229.—*Nature*.

STELLAR PHOTOGRAPHY.

LATELY a good deal has been said about the nebulæ discovered in the Pleiades by means of photography; it has even been asserted that photography had seen more than the human eye. This sounds very nice, but is saying almost a little too much. Dr. Nasselberg, from the Observatory of Pulkowa, writes to me about this: "It is said that the Maja Nebulæ of the Pleiades, first discovered by photography, could not yet have been discovered optically, even with the largest telescope. This is not the case. The nebulæ have not only been seen with great facility by several astronomers, among others by myself, with a 30 inch refractor, but Mr. Struve has also observed the same and made a drawing of it, as can be seen in No. 2,719 (March 4) of the *Astronomische Nachrichten*. Not only with the 30 inch refractor, even with the 15 inch it could be seen plainly." Otherwise Dr. Nasselberg recognizes fully the meritorious labors of the Henry brothers in being the first to photograph the nebulæ. They proceeded with the greatest ingenuity. To be able to control unchanged the position of the total pictures of the stars on the plate with the necessary exactness, they united to their apparatus a second large refractor with 9 inch opening, making one system, so that the whole forms one double telescope, which upon its parallactic mounting follows the stars by clockwork. On the micrometer apparatus of the second refractor the observer can watch the clockwork during exposure constantly, and, the slightest irregularity taking place, he can place the position of a star back again upon the cross line by means of the fine mechanical arrangements of the instrument. Thereby he is enabled to obtain views upon which the stars appear like sharp circular disks, whose size is generally satisfactory in proportion to the luminous size of the stars. Such are the views taken by the Henry brothers. To prevent little spots that may accidentally appear upon the plates being taken for small stars, Messrs. Henry upon each plate always make three views, changing the telescope a little, so that these views will appear each time, forming a triangle, thus ∴. The distance between each spot is about five seconds, and these spots are only visible upon the plate with the aid of the microscope, and then very handsomely.—*H. W. Vogel, Anthony's Bulletin.*

PRINTING METALLIC POWDERS TO STAND WASHING.—M. Dietze proposes to obtain printed designs on fabrics or yarns by means of metallic powders which should resist washing. The patentee employs, for instance, a composition of 100 parts boiled linseed oil, 80 parts starch, 40 parts bronze powder. After mixing the materials intimately, the brilliancy of the impressions may be increased by grinding in the same mixture a variable amount of bronze powder. After printing, the fabric is either calendered or ironed with a hot iron, according to the size of the material.

DISINFECTION BY HEAT.

THE Annual Report for 1884 of the Medical Officer of the Local Government Board, London, contained a memoir, by Dr. H. F. Parsons, on the subject of disinfection by heat. Of this memoir the leading points are here given.

In considering the applicability of heat as a means of disinfection, several distinct questions present themselves for solution. It has first of all to be determined what degree of heat and duration of exposure are necessary under different conditions, as of moisture and dryness, in order to destroy with certainty the activity of the contagia of infectious diseases.

We have next to ascertain how the required degree of heat may be made to penetrate through bulky and badly conducting articles, *e. g.*, of clothing and bedding, for the disinfection of which the application of heat is especially employed.

We have also to learn whether such articles can be submitted to the required degree of heat without injury, for, if not, disinfection presents little advantage over destruction.

After giving a *resume* of the results of previous experiments to ascertain the degree of heat necessary to destroy the contagia of infectious diseases, from those of Dr. Henry, published in the *Philosophical Magazine* for 1831, to those of Koch and his coadjutors (*Mittheilungen aus dem kaiserlichen Gesundheitsamte*, Berlin, 1881), the author states the results of a series of experiments made by him in conjunction with Dr. Klein, who prepared the infective materials, and, after these had been exposed to disinfecting processes, tested the results by inoculation on animals; control inoculations with unheated portions of the same materials being also in all cases made.

The following were the infective materials employed:

1. Blood of Guinea pig dead of anthrax, containing bacillus anthracis without spores.
2. Pure cultivation of bacillus anthracis in rabbit broth, without spores.
3. Cultivation of bacillus anthracis in gelatine, with spores.
4. Cultivation of bacillus of swine fever (infectious pneumo-enteritis of the pig) in pork broth.
5. Tuberculous pus, from an abscess in a Guinea pig which had been inoculated with tubercle.

Infectious pneumo-enteritis of the pig (swine fever) has been shown by Dr. Klein to be caused by the introduction into the body of the affected animal of a specific bacillus. This disease among pigs is highly infectious, the contagium being transmissible from pig to pig through the air, and persisting in infected buildings in a similar manner to the observed behavior of smallpox and scarlet fever among human beings; and, though not transmissible to mankind, it can be inoculated upon rodents, although in the latter animals it is not contracted by infection received through the air.

The experiments on the disinfecting power of dry heat were mostly made in a copper hot air bath, or in one improvised of flower pots, and furnished with a Bunsen's regulator; those with steam were made in a felt-covered tin cylinder, through which passed a stream of steam from a kettle beneath.

The mode of procedure in exposing the materials to heat was as follows: Strips of clean flannel were steeped in the respective infective fluids, dried in the air, wrapped separately and loosely in a single layer of thin blotting-paper, and suspended in the center of the apparatus in company with a thermometer, so placed that its bulb was close to the packets of infected material.

The following were the results of the experiments with dry heat:

Anthrax bacilli without spores were sterilized by exposure for five minutes only to a dry heat varying between 212° and 218° F.

Spore-bearing cultivations of the bacillus anthracis, on the other hand, did not lose their vitality by a two hours' exposure to 220° F., but were sterilized by exposure for four hours to 220° F., or one hour to 245° F.

A rabbit inoculated with swine fever virus which had been exposed to dry heat varying between 212° and 218° F. for an hour remained well; but one inoculated with virus exposed to a similar heat for only five minutes died of swine fever after nineteen days, the usual time of death after inoculation being between five and eight days.

Guinea pigs inoculated with tuberculous pus exposed for five minutes to 220° F. remained well.

The foregoing results, as far as regards anthrax, are far more favorable to the efficacy of dry heat as a disinfecting agent than those of Koch. It appears that the spores of the bacillus anthracis lost their vitality, or at any rate their pathogenic quality, after exposure for four hours to a temperature a little over the boiling point of water, or for one hour to a temperature of 245° F. Non-spore-bearing bacilli of anthrax and of swine fever were rendered inert by exposure for an hour to a temperature of 212°-218°, and even five minutes' exposure to this temperature sufficed to destroy the vitality of the former and impair that of the latter.

As none of the infectious diseases for the extirpation of which measures of disinfection are in practice commonly required are known to depend upon the presence of bacilli in a spore-bearing condition, it is concluded that, as far as our present knowledge goes, their contagia are not likely to retain their activity after being heated for an hour to 220° F.

In the experiments with steam, the results were conclusive as to the destructive power of steam at 212° F. upon all the contagia submitted to its action. In one instance only was there room for suspicion that the disinfection had not been complete; this was in the case of the highly resisting anthrax spores, exposed to steam for five minutes only. The animal had six days afterward a swelling at the seat of inoculation, but remained well. On the other hand, the animals inoculated with unheated portions of the same materials all died.

These results are in accordance with those of Koch, Gaffky, and Loffler, and it may be considered established that the complete penetration of an object by steam heat for more than five minutes is sufficient for its thorough disinfection.

In view of the above satisfactory results, it was not deemed necessary to make any experiments as to the disinfecting power of steam at higher temperatures or under pressure, its efficacy being taken for granted.

Dr. Klein found that boiling in water for only one minute was sufficient to render inert the spores of the bacillus anthracis, although it is known that some of the spore-bearing non-pathogenic bacilli are only destroyed by prolonged boiling, or by a moist temperature above the boiling point.

Some observations were made on the destruction of lice by heat. It was found that the eggs of lice could be conveniently hatched by tying up tightly in muslin a small piece of the garment on which they were deposited, and carrying it about for a week or two in a warm pocket. Tested in this way, no development was found to take place in eggs of lice which had been exposed for one hour to 300° F. dry heat, for one hour to 230° F. dry heat, or for ten minutes to steam at 212° F., or which had been boiled for five minutes in water. The maximum heat which lice or their eggs will bear with impunity was not ascertained.

In order to secure the thorough and certain disinfection by heat of porous articles likely to retain infection, such as clothing and bedding, it is necessary that the heat should be made to permeate the articles in every part to such a degree and for such a length of time as to destroy all infectious matter which they may contain.

It has been remarked that such articles as bedding and blankets are the highest outcomes of the ingenuity of man to check the passage of heat from one side of the object to the other. It is no wonder, therefore, that they should be found difficult of penetration by heat. Even thin layers, however, of badly conducting substances interpose a considerable barrier to the passage of dry heat. The following experiment was made to ascertain how far the inclosing of infective objects in blotting-paper or test-tubes plugged with cotton wool (as in Dr. Koch's experiments) hindered the full access of heat to them.

Two similar registering thermometers were taken. The bulb of one was tied up in a single layer of thin white blotting-paper; that of the other was placed in a test-tube ⅝ inch wide, in such a manner as not to touch the sides, and a plug of white cotton wool 1 inch deep was pushed into the tube around the stem of the thermometer, but not as far as the bulb. Both the paper and cotton wool were previously dried. The two thermometers, together with another with bare bulb, were then hung up in a hot-air bath. Heat being applied, the thermometers were read half hourly as follows:

Time from lighting.	Bare ° F.	Readings of thermometer with bulb In paper, ° F.	In tube, ° F.
½ hour ..	163	.. 147	.. 151
1 " ..	212	.. 193	.. 196
1½ hours ..	234	.. 213	.. 219
2 " ..	243	.. 236	.. 238
2½ " ..	244	.. 244	.. 244

The following experiment was made with a thermometer having the bulb covered with a single layer of blanket, and placed in the hot-air bath already heated:

Time from placing in hot air bath.	Thermometer with bulb bare, ° F.	Thermometer with bulb in blanket, ° F.
½ hour ..	246	.. 231
1 " ..	260	.. 250
1½ hours ..	266	.. 254
2 " ..	268	.. 263
2½ " ..	268	.. 264

Experiments made with larger articles and apparatus showed how difficult it was to secure the penetration of a dry heat sufficient for disinfection into the interior of such an object as a pillow. It was only effected by employing a high degree of heat, or by continuing the exposure during many hours, length of exposure compensating for a lower degree of heat. On the other hand, heat in the form of steam penetrates much more rapidly than dry heat. Thus a thermometer in a roll of dry flannel placed in a hot-air bath at 212° F., at the end of an hour registered only 130° F. In the same roll, placed in the steam cylinder for ten minutes, the thermometer marked 212° F. Experiments on the large scale were equally conclusive. The causes of the superior penetrative power of heat in the form of steam over hot air appear to be:

1. The large amount of latent heat in steam, set free on its condensation. In hot dry air, on the other hand, the evaporation of hygroscopic moisture takes up heat, and delays the attainment of the required temperature.
2. Steam, on condensation into water, occupies but a very small fraction of its former volume, and thus makes room for more. Hot air, in cooling, diminishes in volume in much less proportion.
3. The heat evolved in the moistening of a dry porous substance. In the center of a highly dried roll of flannel placed in the cylinder in a current of steam at 212° F., a thermometer, after five minutes' exposure, registered 239° F.
4. The higher specific heat of steam than of air.
5. The greater diffusive power of steam than of air.
6. The effects of pressure. By applying steam under pressure, relaxed and reapplied from time to time, so as to displace the cold air remaining in the interstices of the material, we have a means of considerably increasing the penetrative power of the steam.

In view of the superior efficacy of steam, both in the destruction of infective matters and in the penetration of badly conducting materials, some experiments were made with moist air in the hope that it might be found possible to obtain the advantages of the use of steam without its drawbacks.

In these experiments either an evaporating vessel containing water was placed at the bottom of the hot air chamber, or steam evolved in a separate boiler was led into the chamber by a pipe.

An attempt was made to measure the degree of humidity of the air by suspending in the chamber two maximum registering thermometers arranged side by side, one of them having its bulb covered with gauze kept moist by dipping in a vial of water, as in the wet and dry bulb arrangement employed by meteorologists. It appears, however, that there are no tables or formulæ in existence by which the degree of humidity of the air corresponding to a given difference between the wet and dry bulb thermometers at these high temperatures can be ascertained. The conditions in a heated chamber are so different from those met with in meteorological practice, that it is doubtful whether the relative humidity of the air could be obtained in this way with any great degree of accuracy; but a comparison of the readings of the wet and dry bulb thermometers was found in practice to be useful as a rough indication of the dryness or dampness of the air, although the readings could not be reduced to a common measure.

The experiments seem to show conclusively that moistening the air of the heated chamber diminishes the time necessary for the penetration of heat into a badly conducting object. As examples the following observations may be quoted. They were made in an iron chamber heated by a furnace underneath, and furnished with a pipe by which steam could be admitted.

		No steam admitted.	A small jet of steam admitted.	Large jet of steam admitted.
Maximum readings of thermometers hung up in chamber	Dry bulb..	299° F.	299° F.	249° F.
	Wet bulb.	140°	165°	190°
Temperature attained in center of similar pillows exposed for one hour in heated chamber.		180°	188°	209°

The moistening of the air of the heated chamber by either method was further found to have the advantage of rendering more equable the distribution of temperature in different parts of the chamber, thus tending to prevent scorching of the articles placed therein.

On the other hand, it was not found that the presence of moisture in proportions such as these, or even greater, increased the disinfecting effect at the temperature employed; spores of the bacillus anthracis retained their vitality equally well in heated air whether it were moist or dry; thus they caused the death of a Guinea pig after exposure for an hour to a temperature of { dry bulb 220° F. / wet bulb 190° F. } whereas five minutes' exposure to a current of steam at 212° F. was sufficient to render them inert.

To avoid risk of injury to articles subjected to disinfection by heat is an important practical question, not only on account of the value of the articles themselves, but also because, if the exposing of such articles to heat be attended with risk of injury, there is danger lest, to avoid this risk, they may not be sufficiently heated to insure disinfection. The following are the principal modes in which injury may occur. They are somewhat different in the case of steam from that of dry heat:

1. Scorching or partial decomposition of organic substances by heat. In its incipient stages this manifests itself by changes of color, changes of texture, and weakening of strength.
2. Overdrying, rendering materials brittle (by dry heat).
3. Fixing of stains, so that they will not wash out.
4. Melting of fusible substances, as wax and varnish, and ignition of matches accidentally left in pockets.
5. Alterations in color, gloss, etc., of dyed and finished goods.
6. Shrinkage and felting together of woolen materials.
7. Wetting (by steam).

Scorching begins to occur at different temperatures with different materials, white wool being soonest affected. It is especially apt to occur where the heat is in the radiant form. To avoid risk of scorching, the heat should not be allowed much to exceed 250° F., and even this temperature is too high for white woolen articles.

By a heat of 212° and upward, whether dry or moist, many kinds of stains are fixed in fabrics so that they will not wash out. This is a serious obstacle in the way of the employment of heat for the disinfection previous to washing of linen, etc., soiled by the discharges of the sick.

Steam disinfection is inapplicable in the case of leather, or of articles that will not bear wetting. It causes a certain amount of shrinkage in textile materials, about as much as an ordinary washing. The wetting effect of the steam may be diminished by surrounding the chamber with a jacket containing steam at a higher pressure, so as to superheat the steam in the chamber.

For articles that will stand it, washing in boiling water (with due precautions against reinfection) may be relied on as an efficient means of disinfection. It is necessary, however, that before boiling the grosser dirt should be removed by a preliminary soaking in cold water. This should be done before the linen leaves the infected place.

The objects for which disinfection by dry heat or steam is especially applicable are such as will not bear boiling in water, *e. g.*, bedding, blankets, carpets, and cloth clothes generally.

Apparatus for disinfection by heat may be classified as follows:

(a) *By hot air:*
1. Apparatus in which the heat is applied to the outside of the chamber, and the products of combustion do not enter the interior.
2. Apparatus in which the heated products of combustion enter the interior.
3. Apparatus heated by steam or hot water circulating in closed pipes.
4. Apparatus in which air previously heated is blown into the chamber.

(b) *By steam:*
5. By a current of free steam.
6. By steam confined in a chamber at pressures above that of the atmosphere.

The most important requisites of a good apparatus for disinfection by heat are (*a*) that the temperature in the interior shall be uniformly distributed; (*b*) that it shall be capable of being maintained constant for the time during which the operation extends; and (*c*) that there shall be some trustworthy indication of the actual temperature of the interior at any given moment. Unless these conditions be fulfilled, there is risk, on the one hand, that articles exposed to heat may be scorched, or on the other hand that, through anxiety to avoid

such an accident, the opposite error may be incurred, and that the articles may not be sufficiently heated to insure their disinfection.

In dry heat chambers the requirement (a) is often very far from being fulfilled, the temperature in different parts of the chamber varying sometimes by as much as 100°. This is especially the case in apparatus heated by the direct application of heat to the floor or sides of the chamber. The distribution of temperature is more uniform in proportion as the source of heat is removed from the chamber, so that the latter is heated by currents of hot air rather than by radiation.

There is a marked difference between the distribution of temperature in a chamber heated primarily by radiant heat and in one heated by the admission of hot air or steam. Radiant heat is most intense close to its source, diminishing rapidly as we recede therefrom. Also it does not turn corners, and thus objects lying behind others are screened from it, except so far as it may be reflected upon them from other surfaces. The rays strike the walls of the chamber and objects therein, so that these are more hightly heated than the air, which becomes heated only secondarily by contact with them.

On the other hand, if air already heated, or steam, be admitted into a chamber, the temperature tends to equalize itself in the different parts, and the walls and solid contents of the chamber do not become hotter than the air.

In chambers heated by gas, when once the required temperature has been attained, but little attention is necessary to maintain it uniform, and in the best made apparatus this is automatically performed by a thermo-regulator. On the other hand, in apparatus heated by coal or coke the temperature continually tends to vary, and can only be maintained uniform by constant attention on the part of the stoker.

In very few hot air chambers did the thermometer with which the apparatus was provided afford a trustworthy indication of the temperature of the interior; in some instances there was an error of as much as 100° F. This is due to the thermometer, for reasons of safety and accessibility, being placed in the coolest part of the chamber, and to the bulb being inclosed for protection in a metal tube which screens it from the full access of heat. The difficulty may be overcome by using, instead of a thermometer, a pyrometer actuated by a metal rod extending across the interior of the chamber.

In steam apparatus the three requirements above mentioned are all satisfactorily met, and for this reason, as well as on account of the greater rapidity and certainty of action of steam, both in penetrating badly conductive materials and in destroying contagia, steam chambers are, in Dr. Parsons' opinion, greatly preferable to those in which dry heat is employed.

It is important that the arrangements of the apparatus, the method of working, and the mode of conveyance to and fro, should be such as to obviate risk of articles which have been submitted to disinfection coming into contact with others which are infected.

The latter part of the report is taken up with descriptions of the various forms of apparatus in use for disinfection by heat and accounts of experiments made with a view to test their practical efficiency.

THE TREATMENT OF CONSTIPATION.*

By HENRY M. FIELD, M.D.

THE physiological resources—or, better still, the resources answering to physiological indication—which the physician has at his command for the relief and cure of chronic constipation may, for the purposes of analysis and classification, be referred to three subdivisions:

First.—Chronic constipation is quite often habitual constipation, and is to be most effectually combated by habitual and systematic attention to the demands of nature in a periodic evacuation of the bowels. Success along this line involves exceptional intelligence and resolution and confidence on the part of the patient. The poet Cowper has well expressed the difference of task in the formation of a habit and reformation in the stanza:

"Habits are soon assumed; but when we strive
To strip them off, 'tis being flayed alive!"

It is far easier to swallow an occasional or a frequent pill than it is to adopt the system required for the removal of a bad habit in respect of constipation; and the patient, whose interest and confidence can be enlisted at first, too often loses faith in herself or the system, and, indeed, in the doctor. The young woman who has been so badly trained in her maternal home—and cases of this kind, throughout our best families even, are innumerable—that she has no other notion of the natural functions of the bowels than that response is to be made only to an emphatic call, an experience which may happen once in three or four days, or once a week, or less often, and who receives as a new revelation the statement of her physician that there should be alvine evacuation daily, at a regular hour, and the most rigid system observed in this particular, has no light occupation before her in an effort to inaugurate reform after so many years of inattention and irregularity. But such task has been repeatedly accomplished upon the condition of a fairly good constitution, of certain measures chiefly dietetic and hygienic of help, and of determined perseverance; and constipation thus cured is effectually and permanently cured.

The patient is to be instructed to select that hour of the day best in consonance with previous habits and least liable to interruption,† and invariably, as the hour comes round, to make an effort at stool, even though there be no solicitation, and notwithstanding there should be frequent non-success. So inevitably is man the creature of habit in every realm of his being, that the patient who invariably and resolutely attempts to perform any physiological function at a stated hour every day will very surely, after a time, carry out his purpose; and the more especially in the present instance, if he have every assistance from a carefully adapted regimen. Of course, any physiological law whatever must have intelligent interpretation; and allowance must be made for occasional departure from the usual standard. There are patients who have excellent health upon the basis of a regular movement of the bowels once in forty-eight hours; and my preceptor, Dr. Peaslee, used to report the case, observed in one of his families, where both husband and wife, then arrived at old age, had each been accustomed for many years, if not through life, to evacuate the bowels only once in nine days! It is the principle of regularity that is to be insisted upon; and a single occasion of failure or neglect, in an individual whose bad habit of constipation had been largely corrected, may cause a serious relapse into the old and depraved method, or lack of method, of life.

Details can hardly be expected from a paper which is confessedly but fragmentary and suggestive. It is to be understood that the regimen which is to assist the patient in the formation of a new habit shall receive the largest construction, and be the object of a special application in every case. Whatever best offers assistance, whether from the department of hygiene or dietetics, is to be laid under contribution. Such appliances as the electric battery, the electric belt, localized massage, kneading of the bowels, etc., have a high and, indeed, an essential value in some instances.

But all cases of habitual constipation, as already intimated, are not susceptible of cure by the scheme of the formation of a new and correct habit, and this for various reasons; probably those cured and capable of cure, at least as found in adult life, are quite exceptional. The patient cannot and will not persevere in the necessary effort; the bowels, long used to overdistension and torpor, will not respond to the most positive and alimentive stimuli; help must be had from medicine, and this medicine drawn from the class of cathartics. What is a cathartic? I have frequently found occasion to say that the definition of anything pertaining to special therapeutics must squarely meet three conditions, if it is to be depended upon to convey the requisite information. It must be intelligible and concise and comprehensive. Judged by such standard, I know not where, in any of all the books devoted to therapeutics, we shall find a satisfactory definition of cathartic. Fothergill approaches the requirement of the case, and yet his terms are not quite free from fault. The following, therefore, is proposed for approval or criticism: A cathartic is an agent or agency which increases both peristalsis and intestinal secretion—either element of action, ordinarily, being prominent according to the material used—with result of provoking preternaturally free and frequent evacuation of the bowels.

There is no need to remind you of recent physiological experiments which have established the fact that every agent which acts cathartically, even though the influence be of that mild degree recognized as laxative, does so by procuring both hypersection and increase of contractility. One agent acts chiefly on the glandular structure, and the stools will be watery; another acts mostly through energized peristalsis, and the dejections are feculent, as with Epsom salts in the former case, and senna and aloes in the latter. There is one purgative, and perhaps only one, catharsis from which appears to present equivalence of action, viz., castor oil—a consideration which, together with the conjoined fact of nearly equable distribution of influence throughout the entire intestinal tract, renders this offensive medicament too often essential to the physician. With an occasional laxative in an occasional subject, energized contractility may be so little pronounced that the serous effusion evoked may remain in the bowel—unless reabsorbed—until some peristaltic is administered to procure its evacuation. But none the less is it true physiologically that the two elements specified always inhere to cathartic medication, and, in variable degrees, are always present in the operation of a cathartic remedy; and the recognition of this principle is essential to the successful employment of this class of materials.

Again, cathartics vary materially in their action regionally considered; *e. g.*, senna acts chiefly on the small intestines, and aloes on the lower bowel. Some, like jalap, and especially elaterium, act so high up as frequently to involve the stomach in the irritation produced, and occasion nausea and even vomiting. It should be borne in mind that the selection of a cathartic, with respect of its operation cathartically upon the small or the large bowel, must have a very important bearing upon the alimentation and nutrition of the patient, for a cathartic which acts energetically upon the upper bowel, and so sweeps it of nutritive material upon which the energies of digestion have been already expended, and which is *in situ* and in process of and for assimilation, depresses the patient far more seriously than does the emetic which simply evacuates the stomach of undigested or indigestible food; while, *per contra*, the other purgative, which gives its force only to the larger bowel, can bring away little more than residual and excrementitious matter.

Still another fact must receive the attention of the physician who expects to employ a cathartic safely and effectively. Some purgative materials exert an influence, near or remote as concerns other organs, of which it is not practicable to take account in any definition of catharsis. In addition to modified action in the function of muscular and glandular structures, rhubarb and magnesia, prominently, effect important changes in the morbid condition of the mucosa of the intestine; and the facts that mercury is indicated in certain functional disturbances of the liver, and that aloes is contraindicated in morbid lesion of the rectum and uterus—familiar to every physician—are sufficient illustrations of the principle which we would emphasize.

Each subject of chronic constipation, requiring help from cathartic medication, must be regarded as a special problem, and, as it were, to be carefully solved before effectual aid can be afforded. An attempt to apply the methods of a routine practice will quite surely bring disaster or disappointment. The physiological characteristics of the prominent cathartics being already understood, it is now to be determined what are the individual peculiarities of the patient who presents himself for treatment. Is the constipation to be traced to inertia of muscle? and is this located chiefly in the large or small bowel? Or, again, is the prominent defect referable to a generally defective secretion from the glandular apparatus of perhaps the entire canal? If it is that great gland, the liver, without the normal working of which no important task of either stomach or bowels can be healthily performed, if it is the liver that is at fault, it should go without saying that no therapeutic measures directed against constipation can be really remedial which do not insure the return of the bile, in proper quantity and quality, to the intestine. The researches of Rutherford, in particular, among recent physiologists, have provided us with new materials for service in this direction; but all the negative conclusions of all the physiologists from the time of Bennett have not availed to release the clinical physician from primary, if not inevitable, dependence upon mercury, in all conditions which unmistakably indicate recourse to a cholagogue.

If it is a weak and anæmic woman, whose symptoms point to torpor located in the small intestine, it will be a difficult task so to adjust medication as to restore activity, procure systematic evacuation, and yet not seriously to deplete. On the other hand, the individual who habitually over-eats, and who is consequently plethoric and perhaps bilious and constipated, will, in addition to a timely mercurial, find an admirable resource in the frequent use of the mildly saline cathartic waters, such as Hunyadi, etc., so popular nowadays; popular, doubtless, because their special role has come to be so generally recognized by the large class requiring such intervention. At the same time, it may be questioned whether the practice of the Roman epicure, in the employment of the emetic, as Seneca gives it—"They vomited that they might eat, and they ate that they might vomit"—was not more physiological, as it was surely more direct in its purpose and results.

Probably no one material belonging strictly to the class of purgatives is so valuable to the physician in the treatment of chronic constipation as nux vomica, classified elsewhere; and because, whatever other element may be present, a deficient tonicity is quite sure to complicate the worst cases of this affection. Nux vomica is the great neurotic energizer of digestion; it is to the nervous element in digestion what pepsin is as a catalytic, and it is the great peristaltic. Many cases can be successfully treated without help of other medicine than nux vomica, though dependent upon the measures specified in the first section of this paper. Still further, the consideration that nux vomica has much of the stomachic properties of the simple bitter, combined with the component power of quinia, renders it the more valuable in such application. Again, nux vomica is valuable because the energy for a specifically peristaltic cathartic is much enhanced by its combination; so that, *e. g.*, the fraction of a grain of aloes may prove as effective in union with nux vomica as would a large integral dose of aloes alone.

Once more, the elimination by the pharmaceutical chemist of the active principles of aloes is a fact of much importance in the treatment of habitual constipation; as far, at least, as aloetics are applicable. Thereby much greater concentration is secured, and not this alone, but the essential oil, which is largely responsible for the nauseous smell and taste of aloes, is avoided, and it is no longer obligatory upon the physician, in his offer of a purgative, to present a bulky and offensive medicament. A parvule constituted of aloin and nux vomica, āā gr. ⅓; or of aloin gr. ⅓, strychnia sulphate gr. $\frac{1}{30}$, with addition of *gr.* j ext. hyoscyamus, to be taken after meals once or thrice daily *pr. r. n.*, provides a resource more generally appropriate than perhaps any other that can be devised.

But aloetics have a wide and varied range of contraindication. It is pretty surely true, notwithstanding the assertion of some authorities to the contrary, that the habitual dependence upon the smallest dose of aloes will gravely increase any active disease of either rectum or uterus. For the subject of chronic constipation, with complicating hemorrhoids or metrorrhagia, or uterine inflammation, it is a difficult thing to find a substitute for the aloetic pill. But the introduction of cascara sagrada has rendered the task easier, and a pill made of nux vomica with gr. j–ij extract cascara sagrada will sometimes meet the latter indication admirably.

It is an accepted statement with the therapeutic physiologist that physostigma increases secretion along the course of the alimentary canal; and physiologically considered, there should be provided a mild laxative in a combination of nux vomica and physostigma as setting in active operation the two essential factors of a cathartic influence. At all events, physostigma introduced into the aperient pill should meet a corresponding indication, as respects the glandular structure of the bowel, with nux vomica in its action upon the muscular coat. From my own limited clinical experience with the former remedy, I have failed thus far to be satisfied of this fact; but in the subject of chronic constipation with prevalently dry dejections, it would receive the sanction of the authorities to combine a fraction of a grain of physostigma with the ingredient of the aperient pill.

Finally, idiosyncrasy is the occasion of much concern in the systematic and habitual use of cathartic remedies; it is doubtful if individual peculiarities assert themselves more arbitrarily in reference to neurotic remedies than in such employment of cathartics. If the patient is a female, and especially if she has been long pampered by habits of self-indulgence and luxurious living, the case must be very carefully studied upon its own merits and demerits, or the physician will quite surely go wrong. The selection of remedies having been made and their apportionment decided upon, it is well that the patient should understand that no two cases of constipation ever required exactly the same treatment, and that quite likely there must be repeated trial and modification of the measure proposed and report to the physician before an exact adaptation can be made in the present instance. Large experience does not always bring confidence; a large experience in the treatment of chronic constipation rather brings distrust, *i. e.*, to the physician; and it is right that the patient should, at the start, be imbued with a measure of distrust and acquainted with the reasons for it, alike in justice to the doctor, the system, and himself. Many patients will not meet the inevitable conditions, they soon get discouraged or are satisfied with partial results; but when the physician can secure such co-operation, it is assuredly alone his fault

* Read before the Gynæcological Society of Boston, May 20, 1886.

† The hour best in consonance with previous habits, etc. Not necessarily at early morning hour, although such is doubtless the hour observed by the majority of those who have established a habit of regularity. A short-sighted effort to force a particular hour upon a patient who had individual reasons for the selection of some other period of the day, has been sufficient to bring discouragement and failure in some instances known to the writer.

if the treatment is not at last reduced to successful terms.

There are, however, some general facts in the employment of special cathartic materials, of which the following must serve as illustrations; and the more of such the practitioner may have at command, the less often will he commit a deplorable error:

1. The salines do not commonly agree with the aged—they find them too chilling; and a dose of Epsom salts which may operate very kindly upon the young and middle-aged and vigorous, may bring serious disaster to the old man or old woman. A sudden depression of vital energy and the function of calorification thus procured, together with other favoring circumstances, have more than once precipitated the subject into a fatal pneumonia.

2. All cathartics are apt to be attended with colicky complications when given to a woman at the epoch of menopause; and especial combination at such time, as with carminatives, should be directed against this painful action. Some of the text-books or lectures used to report the case of a young doctor who was dismissed with contumely from a prominent family, upon which he had chiefly depended for the advance of his fortune, because of offense given to the alimentary canal of a patron, through neglect of this precaution.

3. The common domestic cathartic, senna, should never be prescribed to the subject of cumulative constipation or of impacted feces; if there be anything answerable to a fecal plug formed in the course of the small intestine or near the valve, on either side, such a peristaltic cathartic as senna will infallibly occasion serious and even alarming colic before evacuation can be accomplished; and the same restriction applies to a similar use of an integral dose of calomel.*

4. And to make affirmative provision for the subject of the last restriction, in a case of impacted constipation, when it is to be presumed the bowels are more or less distended with hard, dry, knotty, scyabalous masses (and the more imperatively if there be suspicion of complicating typhilitis or perityphilitis), nothing works so safely and so well as Epsom salts, possibly energized with minute doses of tart. emetic, gr. $\frac{1}{17}$ to $\frac{1}{4}$. Or if it be desirable to apply a cautious peristaltic stimulant in this condition, or in whatever condition declares absence of organic contractility in the bowels, nothing else can be so direct in operation as gr. $\frac{1}{10}$ sulphate of strychnia, inserted once or twice in the twenty-four hours in the areolar tissue of the abdominal wall.

5. There is apparent perplexity in providing cathartic medication, whether on occasions of temporary or habitual constipation, for the subject of a prevalent uterine hemorrhage—*i. e.*, menorrhagia or metrorrhagia. Of course, aloetics are absolutely contraindicated, and senna and cascara no less absolutely; unless, indeed, in the exceptional instance where such a remedy as ergot is required. But there is a cathartic or laxative cathartic which deservedly has the reputation of exerting somewhat of inhibitory influence upon hemorrhage from the womb, viz., cream of tartar. It would be hard to name another which, in its action upon the bowels, arouses so little of peristalsis; and it is not possible that cream of tartar, in any degree of action, should stimulate uterine muscles to contraction; while its tendency to reduce temperature, and especially to lower blood pressure, should work favorably for the arrest of hemorrhage, from whatever cause.

The last section of our subject contemplates, if not the cure of habitual constipation, at least an escape from its discomforts and injurious influence upon health, by the systematic use of water enemata; but its discussion must be postponed for want of time. It may be said, however, in closing, that loose and erroneous notions prevail to an extent among the profession even, respecting the value and the consequences of this measure of relief. The rectal syringe, like the uterine pessary, may do incalculable mischief; suitably, appropriately, strictly, and intelligently controlled, it may be of incalculable benefit. In either instance, there must be selection of cases and considerate adaptation. In no other department of medical practice is the tyro in medicine more out of place, as well as the physician who gives but a passing thought to the condition for which he is called to prescribe.—*Journal of American Medical Association.*

* An infusion of senna may, however, be administered as enema when the torpor and distension are mainly located in the large bowel, both safely and effectually. The excitant influence of senna over organic muscular fiber of bladder, and uterus also, was perhaps more familiar to physicians of an older school than to those of the present day.

THE PURIFICATION OF AIR.†

AN EXPERIMENTAL STUDY IN RELATION TO THE REMOVAL FROM THE AIR OF THE DUST OR PARTICULATE MATERIAL SUPPOSED TO PRODUCE YELLOW FEVER, SMALL-POX, AND OTHER INFECTIOUS DISEASES.

By D. PRINCE, M.D.

THE study of the subject in relation to the purification of the air from the particulate material causing, in wounds, putrefaction, erysipelas, and hospital gangrene, has led to further thought in relation to general infectious diseases.

The study of a subject for a special application of principles often opens to the mind the practicability of arranging the details of methods so as to accomplish other objects than those contemplated in the first endeavor.

The writer of this paper has been for two years making an experimental study of expedients for securing a dustless atmosphere for surgical purposes. It is now generally believed that one of the most important causes of the bad behavior of wounds is the prevalence in the air of floating particulate material, the exclusion of which from wounds is important.

After the discovery of oxygen, there came a theory that the decomposition of exudations from wounds and abraded surfaces, attended by foul odors and evidently poisoning the system, was owing to the contact of oxygen.

The history of surgery includes the account of many expedients for excluding oxygen, upon the supposition that the difference in the behavior of subcutaneous injuries from that of open wounds was to be accounted for by the presence of this or some other gas.

† Paper of Dr. D. Prince upon Atmospheric Purification in Relation to Infectious Diseases; presented to the American Public Health Association.

It is not until recently that it has been established beyond dispute that the infection which is chiefly dreaded is not gaseous, but particulate, and capable of being separated from the air in which it floats.

The problem has been to open the abdomen or other part and to keep it open for an hour, if necessary, and, on closing it again, to have it in such a condition, as to material floating in the air, as it would be in if all the proceedings had been carried on subcutaneously.

The attempt to reach this desideratum by water filtration has been successful as to those atmospheric agents occasioning putrefaction. It has been found, however, that the germs of mould get through the showers of water to a limited extent. They are the lightest of germs, and develop most abundantly in wet weather and in damp places. The plan by water has been—first, to moisten the air by steam; to carry it next through a shower of water; to heat it by a stove (except in hot weather), and then to carry it through another spray of water.

The first thought was to secure a purified atmosphere for an operating room, but in the progress of experiment and reflection, the plan was improved so as to secure a current of air thus treated, to envelop the wound itself, so that impurities escaping from the occupants of the room could not come in contact with the wound; being blown away by the blast of pure air.

Finding that air cannot be completely deprived of its floating material by water, attention has been given to the devising of a practicable plan for purification by the passage of air through cotton. The capability of cotton of arresting all particulate material floating in the air is a remarkable discovery. Most interesting details of experiments to prove the power of cotton in arresting the agents of putrefaction changes may be found in the *Popular Science Monthly* for February, 1878, page 476, and March, 1878, page 501, in which the observations of Professor Tyndall upon this subject are related. The fact that a seal of cotton preserves any kind of material from decomposition, provided that the agents of decomposition are not already in it, shows—first, that these agents are not gases; for anything of a gaseous nature goes readily through cotton; and, next, this fact shows that gases do not initiate decomposition, and that particulate material does. This proposition has been so thoroughly worked out by experiment and observation that it is not worth while to go over the proofs. The work of experimentation with culture liquids is greatly facilitated by this knowledge. The experimenter has only to put a plug of sterilized cotton into the mouth of a test tube containin the liquid under observation, and to subject this liquid to daily boiling for a few times, in order to be sure that it is free from organisms, and he has a liquid under circumstances to keep free from decomposition for an indefinite period.

On the introduction of any infectious material to be experimented upon, he is equally free from the annoyance of the introduction of any atmospheric agent, unless the intrusion takes place at the time of opening the cotton seal.

This is really seen to be much more convenient of management than flasks hermetically sealed. The same tubes can be used over and over to any extent. The problem for perpetuating the sterilization of stationary or still air is thus completely worked out. The arrangement for an apartment of many feet in dimensions is as simple as that for a test tube.

The problem now in hand, however, is to secure the sterilization of air in motion, and which can have no boundary wall between it and the ordinary atmosphere.

The use to be made of such air is (1st) to secure to a surface freedom from the influence of septic or pathogenic agencies, at the same time that it is being manipulated for surgical or other purposes; and (2d) to secure for living beings an air to breathe, free from infectious agencies; or to take immediately away the products of exhalation from the lungs and other parts of the body.

A portion of fruit may be sealed in a can by cotton or by solder, and it will keep indefinitely, but a breathing animal, to be free from septic or pathogenic agencies, when these agencies are round about him, must have some other arrangement, by which his own exhalations may be carried away.

If it is intended, in a particular case, to shield a person from the infection of yellow fever in an infected location, the filtration of the air to arrest the particulate material of the infection must permit a perpetual change. This is secured in a great degree by respirators, worn upon the face, which are usually made to sterilize the entering air, and perhaps might be made to sterilize the air of expiration.

To prevent a subject from taking a disease, the filtration of the inspired air is required; and to prevent his imparting a disease, the filtration of the air expired must be secured.

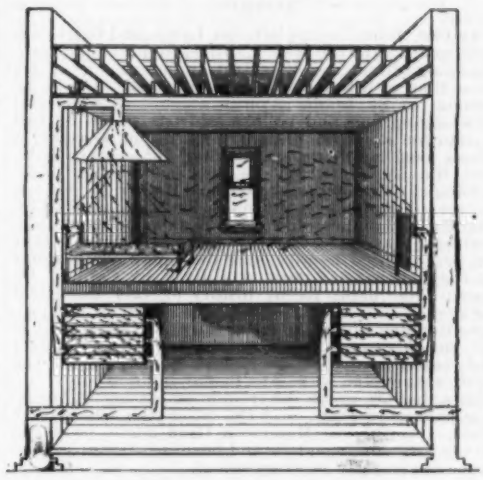
The endeavor, at present on hand, is to secure an arrangement which may take a company of men in an ordinary room and do for them what the respirator is supposed to do for one man. The suction by the expansion of the chest is a force capable of drawing a sufficient quantity of air through the cotton in front of the lips and the nose; but for the face respirator, the problem of sterilizing the expired air has not been worked out, because it would be extremely inconvenient to blow with sufficient force, during each expiration, to propel the expired air through a cotton sterilizer. On a large scale, however, the difficulty vanishes, because it is as easy for a fan to push as to pull.

The device, on the one hand, for blowing the fire of a furnace, and, on the other hand, for sucking away the sawdust of a circular saw in a planing mill, is the finger point toward the arrangement needed. This is an instance in which inventions for particular purposes become equally valuable for far different ends. In any establishment in which there is an engine, or a motor of any kind, the remainder of the detail may be easily worked out.

The problem is not difficult, if the air is to be stationary, but the circumstances require that a considerable quantity of air shall be supplied and be quickly replaced by another supply, in order that the impurities generated may be carried away. All know the effect of a hedge or a strip of forest in arresting the force of the wind in the winter, when there are no leaves, but only the filter of limbs.

What these limbs are to the wind, a layer of cotton is to the current of air employed for the purposes referred to. As it is important for surgical purposes that the sterilized air should have a temperature equal to that of the body, while it is comfortable to have the general air of the room much lower in temperature, there arises the difficulty of the tendency of the warm air to rise to the upper part of the room, instead of enveloping the wound of a patient under operation or surrounding a sick man lying upon a couch. It is entirely practicable to secure a sufficient degree of motion by means of heat if there is not the impeding effect of the cotton.

To overcome this difficulty, the force of a fan is employed, which is run by an engine. By establishing a hurricane on one side of the cotton, a moderate wind is secured on the other, having a force sufficient to overcome the effect of light specific gravity in the warm sterilized air. For surgical purposes, the addition of a small amount of steam is desirable, in order not to dry the exposed moist surfaces, and an arrangement for that purpose is seen in the drawing.



The figure represents a scheme for sterilizing the air which enters a room for protection against infection, and one for sterilizing the air escaping from a patient who is supposed to be afflicted with small-pox or some other infectious disease.

In this scheme the particulate material is supposed to be arrested by the cotton, which, at the end of the necessary period, can be burned.

The arrangement is in the form of a chest of drawers, the outside of the chest being a cube of fifty inches.

There are three drawers, each having an area of cotton 40×40 inches, equal to 1,600 square inches, the area of the three being 4,800 square inches.

There are two air-tight floors: one below the upper shelf and one below the middle shelf.

The air enters above each shelf of cotton, and escapes below it. A sheet of woven wire, with three-quarter inch openings, serves as the support for the cotton, which is about an inch in perpendicular thickness.

For blowing sterilized air into a room, the blower must push. For taking foul air out of a room, the blower must pull.

The arrows show everywhere the course of the current of air.

Observations are in progress to prove the approximation to perfection of this device for depriving the air of the material in it which is capable of starting and perpetuating changes in organic substances.

The value of an expedient like this on shipboard must be obvious at first sight. The patient being confined in an apartment, an arrangement may be made to run by the machinery of the ship, to give him pure air or to purify the air which is poisoned by emanations from him, or both combined.

An experiment to determine the penetrability of cotton by gases while the particulate material is arrested has been made, by burning sulphur in the air previous to its passage through the cotton, and finding that the sulphur dioxide passes readily through, while the particles which ordinarily give a blue tinge to the sulphurized air have been arrested in the cotton mesh, leaving the air perfectly transparent.

CELLULOSE IN TUBERCULOSIS.

CELLULOSE, the principal constituent of the vegetable cell-wall, has been found to occur also in some animals. The mantle of *Phallusia mamillaris* and of Cynthia, and the external coat of Salpa, consist mainly of tunicin, or animal cellulose. Now, a further very valuable contribution to our knowledge of the occurrence of this body has been made in Vienna by Herr Ernst Freund, working at Prof. E. Ludwig's laboratory. Freund has succeeded in preparing, from some of the organs and blood of tuberculous persons, a substance exactly resembling cellulose, and showing all the reactions which have hitherto been described as peculiar to the latter. The reactions employed were the following: 1, conversion of cellulose, when dissolved in concentrated sulphuric acid, into dextrose on boiling with dilute sulphuric acid; 2, resistance if treated with Schultze's reagent, a mixture of nitric acid and chlorate of potassium; 3, yielding of a collodion-like mass by the action of nitric acid and ether; 4, assuming a blue color by the action of iodine in presence of concentrated sulphuric acid or chloride of zinc solution; 5, assuming a violet color by the action of a naphthol when dissolved in concentrated sulphuric acid (Molisch's reaction); 6, insolubility in common (indifferent) solvents (dilute alkalies); 7, solubility in a solution of cupric hydroxide in ammonia. The substance obtained from miliary tubercles and from the blood of tuberculous persons was subjected to ultimate analysis in three cases, and yielded between 45·12 and 44·70 per cent. C, and between 6·41 and 6·19 per cent. H; while 44·74 per cent. C and 6·17 per cent. H corresponds to $C_6H_{10}O_5$. A quantitative determination of the cellulose of the tubercles has not been made. The researches were carried out on material from twenty-

five tuberculous and thirty non-tuberculous cases. The tuberculous material (lungs, spleen, peritoneum with miliary tubercles, blood) embraced cases of conglomerated as well as of infiltrated tuberculosis in the different stages of the disease. The non-tuberculous material examined was taken partly from healthy organs, partly from organs affected by various diseases —as, *e. g.*, from pneumonia, emphysema, pulmonary gangrene—and failed to show any of the reactions described above. Carcinomatous, sarcomatous, lupoid, syphilitic, and other non-tuberculous granulations were also examined, with negative results. From his researches, Herr Freund makes the suggestion that in tuberculous growths, and in the blood of tuberculous persons, cellulose forms an intrinsic constituent. We need not refer to the importance and suggestiveness of Freund's discovery for pathological science, making further researches on this subject very desirable.—*Nature.*

THE HOT SPRINGS OF THE YELLOWSTONE REGION.

IN 1806, John Coulter left the Lewis and Clarke expedition to go to the Missouri River to hunt and trap. Escaping from the Blackfeet Indians, he lived for some time with the Bannock Indians, and in 1810, returning to St. Louis, gave an account of wonderful spouting springs and boiling caldrons which he had seen in the Rocky Mountains. By this he acquired a great local notoriety as the chief of modern liars, and the locality which he described was derisively spoken of by hunters as "Coulter's Hell." In 1844 one James Bridger penetrated to the locality described by Coulter, and on his return was no more believed than had been his predecessor. It was not until 1863 that the first credited description of the region now familiar as the Yellowstone Park was given by Captain De Lacy. The more recent history of this wonderful country is now known by all men. We do not propose to inflict upon our readers any description of it at all, but only to say that after having wandered over the greater part of these United States, except the California region, there are, in our opinion, only two places that are worth the trouble of getting at them: one is Niagara Falls, and the other the Yellowstone Park. Possibly the Mammoth Cave might be added to the list. The wonders and beauties of the Yellowstone can scarcely be exaggerated.

The amount of hot water that is going to waste in the Yellowstone region is sufficient to fill the heart of a Chinese laundryman with an agony of sorrow, and to make an American sanitarian look with pity and disgust upon the small springs of Arkansas and upon the rest of the world with profound contempt. There are in the park simply thousands of hot springs of all magnitudes—some mere pellucid pools, some trickling fountains, some spouting masses of water almost sufficient to supply a city. And it can scarcely be otherwise than that in the future some of these springs will be found to possess very valuable medicinal properties.

Generally speaking, most of the springs can be divided into two sets—the calcareous or calcic and the silicious. The Mammoth Hot Springs are the most important of the calcareous waters. They are really a large collection of springs, which, commingling with one another, have by their conjoint effort deposited a mountain of carbonate of lime. Two of these springs have been analyzed by Dr. Henry Leffmann, of Philadelphia, with the following results. (See U. S. Geological Survey, 1878, part ii., page 389.) The Cleopatra Spring, water strongly alkaline, temperature 154°.

	Grains to imperial gallon.
Sodium chloride	13.496
Sodium sulphate	35.504
Calcium sulphate	13.587
Calcium carbonate	24.850
Magnesium carbonate	7.455
Silica	3.500
	98.392

Spring No. 17. Temperature, 165°. This may be arranged as follows:

	Grains to imperial gallon.
Sodium sulphate	34.370
Sodium chloride	18.900
Calcium carbonate	17.920
Magnesium carbonate	2.170
Silica	3.360
	76.720

A greater number of the Yellowstone springs are silicious, and deposit immense masses, known as geyserite, which contains ninety per cent. of silex. An analysis of one of these, the Opal Spring, a silicious water in the Gibbon Geyser Basin, by Dr. Leffmann, gives the following result:

	Grains to imperial gallon.
Sodium chloride	82.180
Calcium sulphate	3.220
Silica	53.760
Calcium chloride	4.060
	143.220

The analysis of the Jug Spring of the Fire Hole Geyser Basin resulted as follows:

	Grains to imperial gallon.
Sulphuric acid	1.400
Chlorine	19.180
Silica	14.560
Calcium	traces
Sodium	34.440
	69.580

These analyses show that the springs of the Yellowstone are rich in mineral matter. But they do not fairly represent the resources of the region. Many of the waters are certainly strongly alkaline, and the immense masses of sulphur which are to be found in certain portions of the park, as well as the deposits around many of the springs, show that these waters are, some of them, also strongly sulphurous. The so-called Sulphur Mountain is a large butte full of small crystalline deposits of sulphur, and with sufficient sulphur emanations coming up through which to make liquid deposits upon the warm ground at the top—drops of melted sulphur, which might well be spoken of as drops of golden dew.

A member of the United States Geological Survey told us that one of the springs is very rich in boric acid, and that a number of them contain a notable percentage of arsenic. Near the Mammoth Hot Spring is a lake of warm water in which the invalid might well disport himself for hours, suiting the temperature to his needs by shifting his position toward or away from the thermal springs which feed the waters.

The only place that we know of in the Northwest which is at present prepared for the treatment of disease by the use of water and bathing is that which is known as Hunter's Springs. This is situated a few hours' of railroad riding this side of Livingston, near the Yellowstone River, whose rapid waters would afford to the invalid much amusement in the taking of large trout. There are three or four distant springs which furnish a very abundant supply of water, both for drinking and bathing purposes. The hotel, which is just finished, is primitive but sufficient. There is a large bathing pool, which reminded us forcibly of that at the famous baths of Luck, in Switzerland, besides numerous bath tubs, and all necessary arrangements for private bathing. The heat of the main spring is 168° F., and it has a specific gravity of 1·03 at 60° F. No analysis of it has ever been published, but we are enabled to give an original analysis made by Prof. Lehnen, of St. Paul:

	Grains to imperial gallon.
Solid contents	21·76
Magnesium carbonate	3·35
Ferrous carbonate	0·16
Calcium carbonate	1·65
Potassium chloride	2·10
Sodium chloride	0·15
Potassium sulphate	1·68
Sodium sulphate	1·38
Magnesium sulphate	7·07
Calcium sulphate	2·01
Alumina and silica	2 21
	21·76

The amount of solid matter in the Hunter's Spring water is not very great, but there are more salts than are contained in the Hot Springs of Arkansas, and it is probable that syphilitic, rheumatic, and skin affections could be very successfully treated by it. The spring already enjoys a considerable repute in the Territory of Montana, and at the time of our visit there were some eighteen or twenty people undergoing treatment.

Before the thermal springs of the Northwest can attract invalids from distant places, much greater development must certainly take place, and we strongly urge upon the Northern Pacific Railroad authorities the policy of furthering such development. It would certainly pay the railroad, then, to have a thorough exploration of the springs of the park made at their own expense. The United States government, however, as owner of this property, ought to develop it.

Attached to the present United States Geological Survey there should certainly be a chemist, who should have a sufficiently well furnished laboratory in the park to make careful studies on the spot of a large number of these innumerable hot springs. At present there are no facilities in the park for the reception or care of health seekers, although there are large general and well managed hotels, and to them sanitariums could readily be attached.—*Therapeutic Gazette.*

A NEW THEORY OF COAL FORMATION.

THE *Bulletin de la Ceramique* has lately dealt with a theory regarding coal formation which it rightly or wrongly considers of sufficient originality to merit treatment of a detailed character, while the facts are said to reconcile features of the more ancient theories with results obtained by modern experimental science. Ideas of a more or less novel kind have from time to time been put forward by French writers with regard to this subject. M. Gennete asserted that coal is produced from a certain sandy earth which he names agas, while M. De Gonsanne regards it as clay mixed with sufficient bitumen and sulphur to render it combustible. In further illustration of his theory, he quotes the fact that none of the ligneous products with which we are acquainted can, strictly speaking, be called coal; referring specially to lignites, etc. Buffon has indicated the fact that coal deposits are situated in places which were at one time covered with water. Following out this idea, M. De Grand' Eury argues that the water of such seas or lakes was heated by the earth's caloric properties and by the sun. The atmosphere being charged with carbonic acid, there was in these waters an enormous production of inferior vegetation, which absorbed the carbonic acid of the air and became decomposed by the want of either water or oxygen. A sort of vegetable jelly will thus have been formed, which, gradually losing its humidity, transformed its carbon into ulmic hydro-carbureted substances; to become successively transformed into asphalt, petroleum, naphtha, earth pitch, bitumen, and finally coal.

This principle is opposed to the idea that large trees and shrubs produced coal, and in further support of this theory it is stated that the carboniferous flora consisted of plants deficient in substances necessary for producing coal, the investigation of M. Gaston de Saporta on this point indicating that this vegetation consisted of a relatively thin circle of wood and of a large quantity of a softer substance. Brogniart and Elie de Beaumont attribute the formation of coal to the transformation of the close herbaceous vegetation which surrounded the larger forest trees and plains. Similar opinions have been expressed by M. Ponchet and other *savants*, so that M. Grand' Eury has more or less eminent authorities for his statement that a calculation of the accumulation of trees, etc., necessary for the conversion into even a thin coal bed of a forest suddenly buried under water, or gradually letting its residue gather on the ground, leads to an evidently erroneous result, so greatly is it necessary to exaggerate either the mass of vegetable matter or the duration of the process of coal formation.

Even admitting for a moment that coal is produced by the decomposition of trees, M. Grand' Eury asked how it can be maintained that wood in losing its moisture has become liquid. Wood is known to contain a good deal of water, and coal has only traces of it. While he regards it as certain that coal was at one time liquid, and gradually assumed a solid shape, he considers that coal beds were formerly beds of naphtha and bituminous petroleum produced by the decomposition of inferior aquatic vegetation under the influence of heat and dampness. As a proof of this assertion, he quotes the fact that the porous minerals found at the bottom of coal pits are impregnated in their pores with naphtha and petroleum. This is immediately detected by their odor (particularly with the porous minerals of lithoidal carbonate of iron), and it is therefore argued that this naphtha could only have been absorbed during the first state of coal formation. It is further remarked that this theory serves to explain the formation of petroleum, asphalt, and other bituminous springs, which are found at various depths, and even at the bottom of some lakes. A porous soil would allow of filtration, and hence M. Fongas has remarked that in calcareous districts the coal found is usually of poor quality.

In further defense of the hypothesis that coal was once in a liquid state, it is urged that cannel coal lights in the same way as resin, and can be used like a torch or flambeau. Another proof is the fact that the lighter substances (turfs, lignites, etc.) are on the top. Various proofs are furnished by the absence of similarity between the ashes of wood and coal that the two substances are not so closely connected as has been thought to be the case. The presence of fossil imprints or plants is explained by the fact that these imprints are in the earthy and schistous portions of the mines, and not in the coal itself. The trunks of trees which are sometimes found are not coal, properly so called, and retain certain properties of wood. The waters in which there grew the vegetable substances, to which reference has been made, contained (like such waters at the present time) carbonate of lime, carbonate of iron, and alum. Hence the presence of these salts in certain kinds of coal is explained. These interesting facts quoted by Mr. Paul Noel are possibly not altogether new, but in any case deserve attention.

COAL.*

By FRANK CALVERT.

IS coal, as presented in nature, formed exclusively of the remains of primeval forests, or are the vestiges of vegetation in coal the exception, as not constituting the bulk of the general mass of carbonaceous matter? This question forms the subject of the present essay.

The arguments in favor of a vegetable origin have been so generally accepted, that the advance of an opposite opinion may be received, at first sight, as emanating in a spirit of contradiction or of presumption. For many years the vegetous theory was held by the writer as a fundamental belief. Certain facts that present themselves, and the ideas they suggest, have led to the modification of this view, to substitute the hydrocarbons, or bituminous family, as the basis of coal, and to relegate the vegetable remains found therein as incidental matter.

Two theories are held on the vegetable formation of coal—the growth of forests *in situ* and the amassing of drift. The general concave nature of the beds in a coal field, with a depression of a hundred feet or more in its center, evidence forcibly against the theory of the local paludal growth of coal as a rule. If water were present, it would be in the form of a lake. Bogs, moreover, in their growth, assume, generally, a convex shape, that is, higher in the center. Suppose, then, an aquatic vegetation—take a bed of coal, say ten feet (at Wolverhampton thirty) deep, representing an uncompressed bulk of at least double that thickness. The vitality and longevity of stigmaria and other plants, whose roots, embedded in the soil at the bottom of the water, would then be such as to survive an accumulation of twenty feet of vegetable matter. That such extraordinary growth did not exist is proved by the unbroken beds of foreign matter that completely separate the mass in horizontal sections; therefore, the theory of local growth does not meet the case. Again, the hypothesis of an arrested state of subsidence of land, repeated, say fifty times, in the formation of a coal field at long intervals, each interval representing an age, conveniently suspended to allow of a vegetable growth, makes too great a claim on credulity. Submerged forests, with stumps of trees still remaining in the place of growth, are certainly found in the earth's strata, but there is no continuity in the relation of their growth to the bed of coal to establish the fact that they originated the general mass. The dividing nature of the thin beds of foreign matter in the seam of coal already mentioned proves the deposit to have been effected in tranquil waters under conditions in which vegetation, admitting it existed then and there, had not the power to penetrate from below the unbroken plane or its roots to traverse from above. To establish a fresh start of vegetation based on clay or sand a fraction of an inch thick is an inadmissible argument. The older theory of drift vegetation has more claim to attention than the newer idea of local growth. Drift vegetation has contributed certainly to the formation of coal, but this to a limited extent, to what relative degree will be shown farther on. The motive that led to the examination of the subject of the present essay was accidental. Some years since, an eruption of petroleum occurred in the sea off the island of Samothrace, near the Dardanelles. A portion of the mineral entered the straits. As the pieces of bituminous matter neared the shore they grounded and spread on the bottom of the sea in patches, incorporating remains of marine and terrestrial vegetation. The density was nearly equal to that of the water of the sea. The oily portion of the ejected petroleum coming in contact with the water was eliminated to a greater or less degree, while the gravity of the more solid part increased until it sunk and spread on the bed of the sea. These facts suggested the following ideas: Suppose this deposit, in the course of ages, buried under a mass of strata, to have undergone enormous pressure, would not the bituminous substances appear as a seam of glittering coal? Suppose a piece of this coal be cut into very thin slices and submitted to the microscope (as experimented by Hutton), a vegetable texture would be apparent, and a *prima facie* proof of a vegetable origin adduced.

* Recently read before the Greek Literary Syllogos of Constantinople.

The sharpness of outline of vegetation sometimes seen in coal is due to the prophylactic property of the bitumen in which the remains have settled, as the delicate insect is preserved in amber. The process through which the vegetable remains in question have passed may be instanced in a fragment of wood or branch of a plant that has been left to sink in bitumen or in tar. The pores are gradually imbued with the viscid matter, and the minutest fibers or leaf preserved from decay.

The manner of deposition suggested by the eruption of petroleum near Samothrace would be not only more natural than that of local forest growth or drift, but it would explain the formation of the thinner seams of coal. A portion of the petroleum from Samothrace, in my possession for some years past, still retains its viscid consistence, showing the absorption or setting of vegetable matter in a mass of the substance, such as a bed of coal in its nascent state would present, may extend over a considerable period. The form of stigmaria, sigillaria, and other aquatic and terrestrial plants which sink, when saturated with moisture, into the yielding mass, has thus been frequently preserved in coal.

Corroborative evidence is furnished by Nicholas Nugent (Polehampton Gallery, vol. v.), who visited in 1807 the pitch lake in the island of Trinidad. He mentions "pieces of recent wood," and "even large branches of trees enveloped in the bituminous substance." "Some parts of the asphaltum," he informs us, "had a splintery, conchoidal fracture, resembling particular kinds of coal; in others it bubbled up in a perfectly fluid state, so that you may take it up in a cup." Here is presented in a comprehensive view the substance of original matter, the inspissation of the asphaltum, and the presence of vegetation in the first stages of the formation of coal.

The bituminous springs of Albania furnish conclusively a proof of the deposition of bitumen in stratified form. Flowing from the springs, the bitumen leads to the small lake, where it accumulates on its bed. The bitumen is found over an area of several square miles, round the springs, in the form of numerous strata, the deposits of past ages. These strata vary in thickness and in purity, and are interstratified into beds of clay. Convulsions of the earth's surface have displaced in part the prior horizontal position of the beds, some of which dip at a high angle and afford an instructive section of this interesting formation.

The varied nature, the degree of purity of the carbonaceous matter, the diverse conditions it has encountered, has originated the many descriptions of coal, from anthracite to the highly bitumenized Newcastle. It is to be observed that both marine mollusca and vertebrata are found in coal fields, though the proportion to terrestrial is smaller. The accumulation of coal, physically, is more natural in fresh water basins than in the sea, where currents, more or less prevalent, would spread the bitumen into thinner seams.

The general appearance, in some kinds of coal, shows the successive accumulation of portions of semi-fluid bitumen. The form of these pieces approaches the lenticular, such as bituminous matter assumes in setting in water. On the cross section to the general bedding of the coal, these portions appear as elongated patches of varied degrees of brilliancy—an arrangement which is not natural to a vegetable deposit.

From coal proper of bituminous origin are to be separated woody lignite and brown coal (such as may have originated in bogs) and jet. The circumstance of amber being inclosed in jet indicates its origin in the resinous portion of coniferæ which has been preserved, as in the pine forests of the present, while the softer or more resinous part decays. Isolated pieces of coal have had their origin also in the carbonized remains of forest fires, caused by volcanic agency, lightning, friction, or spontaneous combustion. Many pieces of carbonized wood washed down by floods in the Tertiary ages are still preserved, with the characteristic cross fissured appearance wood takes by contraction, when charred.

Bitumen, in disseminated form, has played an important part in the preservation of vegetable matter. Non-resinous plants, for instance reeds, frequently found in a carbonized state embedded in a stratum of rock, would apparently show that coal may be formed independently of bitumen. Opposed to this feature, the next stratum may show identical plants, of which the cast or impression of the leaf or stem remains, while the carbon, or vegetable matter, has been replaced by stone or clay. In these two strata, the plants have been embedded under similar conditions, that is, in an undecayed state. Why is the plant in the one case preserved, and not in the other? The cause may be due to the prophylactic property of the embodying sediment in the first instance, to the absence of the preservative in the second. A shaft made in the boraciferous basin of the Sultan Chair, near the Simaov River (ancient Macestus), in Asia Minor, confirms this hypothesis in a clear manner. While in the bituminous clay and sand the carbonized remains are preserved, the form alone of vegetation remains in the non-bituminous strata. The bituminous clays and boraciferous gypsum of the Miocene basin of Sultan Chair are of volcanic origin. Close to the basin, in the older rocks, are the springs of Lidgia, of a high temperature. At Omerkioi, in the newer rocks, near the edge of the basin, are other sources of a more moderate degree of heat. These springs are charged with carbonic acid.

Bitumen, in attenuated quantity in rocks, from the coal shales to lessening gradations, is common, and sufficient to act as a preservative. Bitumen in different forms is not uncommon in mineral waters. A certain portion of vegetable matter has been undoubtedly converted into coal, still, as has already been remarked, it is far from forming the general constituent bulk of the same.

In the valley of the Dent, in England, a bed of coal a fraction of an inch in thickness is continuous through an area of several miles in diameter. Thinner beds forming attenuated sheets are frequent in coal fields. It is physically impossible the continuous seam of coal, as fine as a sheet of paper, shining with brilliant purity, has had its origin in a deposit of leaves; that time has eliminated the earthy portion of vegetable matter and purified the carbon. The quantity of ash in some kinds of coal is so small as to form but one five-hundredth part of the weight, yet we have the significant fact the component materials of this small quantity of ash differ essentially with that of wood. Taking in general the insoluble portion of ash, lime leads with an average of forty-five per cent. in wood ash as to five, while silica, three per cent., is increased to forty-three in coal. Alumina, the next predominant mineral in coal ash, which furnishes forty-one per cent., is remarkable by its scarcity in the vegetable kingdom. It is interesting to compare the foreign matter in the inspissated asphaltum at Trinidad. In a hundred parts of this matter, there were, according to Nicholas Nugent, sixty of silica, ten of alumina, ten of iron, but not a trace of lime. Silica and alumina are the minerals most frequently held in mechanical suspension in lakes and seas. To the deposition of this sedimentary matter its presence in coal is due, in varying quantity, from a small percentage to rising gradations, through the many varieties of coal to the shales, when carbon takes a secondary position. The purity of coal, devoid of the constituent minerals of wood ash, with but a trace of sedimentary matter, further sustains the hypothesis of a bituminous origin, some varieties of which substance burn without residue.

Assuming the bituminous origin of coal, the question presents itself, from what source the bitumen of which it is composed be derived. The rearrangement of mineral matter in accumulated individual form in sedimentary rocks, as compared to the general homogeneous character of the earth beneath the superficial crust, has originated: First, the great variety of igneous rocks (through which a link of affinity exists), by intense heat acting on, fusing, and destroying the form of the sedimentary rocks. Secondly, the transformation of the constituent minerals in their separated or concentrated form of rock, by the action of comparatively moderate heat, without displacement of the stratified position. To the latter section is to be placed the conversion of carbon, stored in such vast quantities in limestone, under combinations of heat and moisture, to the generation of the hydrocarbon and bituminous group.

Nature gives the faculty to vertebrata and to plants to decompose matter and to form new combinations in the production of fat, oil, and resin. The synthesis of matter on a grander scale, in the mighty laboratory of the earth, is therefore an admissible hypothesis, hence the present source of petroleum and the rest of the bituminous family. Forced through the fissures of the earth, from the locality of generation in the past, the bituminous issue has formed the coal beds of former ages. The process of transformation of the carbon in limestone under required conditions may be continuous, that is, has been and is still in operation in the earlier and succeeding sedimentary rocks, to be continued hereafter in beds in actual course of deposition at the present day.

THE EARTHQUAKE AT CHARLESTON.

To the Editor of the Scientific American:

Referring to my letter of Sept. 18, suggesting a line of inquiry as to causes influencing the recent earthquakes, and the answer of P. M. F. thereto in your issue of Oct. 9, I beg to suggest that the reasons assigned by him in antagonism to the theory are by no means sufficient to divest it of scientific interest, for the reason that they ignore one fundamental fact. He says:

"1. Almost, if not all, of the theories accounting for the presence of gas and petroleum accept the fact that these substances were formed subsequent to the final comparative quiescence of the earth's crust after ages of upheaval and disturbance. This being so, there must have been cavities for the reception of gas and petroleum before they were formed; and if the overlying strata kept their position then, when the cavities were empty, why should they now be disturbed by the withdrawal of the contents of the cavities?"

Accepting all of this as true, he ignores the generally admitted and—in this connection—important fact that the earth is *still gradually cooling and contracting;* and even if the cavities did exist before they were filled with oil and gas, it is perfectly apparent to reason that a contraction of the earth's crust would gradually produce an increased pressure upon the confined cushions of oil and gas until the gravity of the superincumbent mass was balanced, or nearly so, by the degree of compression or elastic resistance of said bodies of oil and gas. Now, after this condition of things has been reached, a ventage of these bodies of oil and gas would leave the crust free to collapse from gravity, and might involve the result predicted in my former letter. That the earth is contracting is generally admitted, and the fact has been, I believe, particularly observable along the Atlantic slope in the gradual encroachment of the sea upon the land, which has been frequently the subject of remark in recent years. This encroachment of the sea upon the land may be fairly taken as *one* evidence of the contraction of the earth, for, as the solid crust contracts, it becomes of smaller diameter, and the body of water on the surface consequently overlaps a larger portion of its circumference.

P. M. F. also, in accounting for the increased presence of the gas by the continued accumulation of oil and gas from its source of generation, says that such pressure would not hinder the chemical combination of materials of which they are formed. Now the transformation or evolution of gas from the heavier hydrocarbons is mainly a question of volatilization, and this *is directly* retarded in proportion to pressure. P. M. F. also, I think, attributes too insignificant an agency to the pressure exerted by this oil or gas. Although the pressure at which it issues at the surface may only reach a few hundred pounds, this does not signify that the pressure which it exerts within is as insignificant, any more than the pressure at the exhaust pipe of a steam engine correctly indicates the pressure within the boiler. It is a fact that the frictional resistance which a fluid meets in passing through a long line of pipe so reduces its pressure at the discharge end as to constitute one of the serious obstacles to the transportation of natural gas; for, although it may enter a pipe line at a high pressure of several hundred pounds, this pressure falls at no great distance to an insignificant figure.

Now, the gas, in passing through the cellular crevices and rough channels of its passageways to the surface of the earth, undoubtedly meets with such great frictional retardation as to cause the few hundred pounds pressure at the surface to represent an original pressure of many thousand pounds in the storage cavities within the earth; and this is no insignificant factor, and may, when depleted by long continued ventage, be sufficient to disturb the balance between gravitation and centrifugal action.

If, however, P. M. F. speaks as one having an intimate acquaintance with the oil and gas regions at the time of the earthquake, his reply is of the very kind that my letter was intended to evoke, and the inquiry must be held to have been fairly answered by his assertion that there was no such disturbance of flow or pressure at that time. While demurring to his philosophy, I am bound to accept his "fact."

EDWARD W. BYRN.

Washington, D. C., Oct. 9, 1886.

THE REARING OF TURKEYS.

By HENRY STEWART.

THE turkey is supposed to be a delicate bird, not easily reared. It would be strange if it were so, considering that the best kind of birds are reared in a state of nature in the forests of the South and Southwest, and grow to a size and vigor quite equal to the domesticated varieties, and yet the wild birds have none of the advantages of the feeding and care which can be given to those reared upon farms. The fact is that the domestication of the turkey has not improved its natural hardiness and vigor, nor has it increased its weight, for wild birds are occasionally seen which are equal to the finest of the domesticated. But yet the domesticated bird is by no means wanting in the natural hardiness of the race, for it is the mistakes of the owners which cause such a very large mortality among the young birds, just as it is the case in the rearing of chickens, of which the larger part are lost by disease in the earlier period of their lives; and the great difficulties which lie in the way of success, and which disappoint the hopes of the farm housewife, are precisely those which interfere with success in rearing chickens, viz., a want of the proper arrangements for controlling the hens during incubation, exposure of the young broods to damp and filth, and overfeeding. From my experience during a good many years, I have found turkeys to be more easily reared than chickens, and no more subject to the fanciful dangers of youthful periods than any other young animals. The greatest danger of all is simply overfeeding—cramming the young things with food which they cannot digest, and of course vitiating all the vital functions, when there is not strength enough to withstand or counteract the injury.

In the care of all sorts of animals whose instincts are peculiar and strong, it is necessary to consider these, and conform the methods of management to them. Thus the hen turkey must be provided with a secluded place for her nest, and this should be on the ground, and in a dry, sheltered place. Some low trained bushes and evergreens are excellent to afford these desirable conveniences for the hens. When the nest is made, and the hen retires, her natural shyness is to be accommodated by leaving her alone, simply putting food (corn is the best) and water somewhere near the nest, where the hen may come quietly and unobserved. At the end of four weeks, the food should be changed to coarsely cracked wheat, rye, and corn, so that the chicks may be fed. When they are a week old, the hen will lead them out to forage, and the coop in which the nest has been made may be brought out into the yard, where the active little creatures can find a good range. As these birds are quite ornamental, and do no damage, the lawn may be given up to them for a range until they are 12 weeks old, when the coops will no longer be wanted, and a hundred acres will hardly suffice to contain a brood. The coops should be placed among the shubbery, and on dry ground, and be moved every two days to a clean place. The coops are much the same in every way as those for chickens, but larger—4 feet long, 2½ feet wide at the bottom, and roof-shaped, leaving the peak 2½ feet high. This gives ample room for the young birds when confined during stormy, cold days, or in sudden heavy rains. It is necessary to keep a watch for these storms, and during the first 8 or 10 weeks of their life to drive the young ones up to the coops for shelter, when rain is seen to be approaching.

The feed need consist only of corn, rye, and buckwheat coarsely ground together, and should be given in small quantities frequently. Half a pint of food is sufficient for the hen and 10 or 12 young ones at once, and this may be given four times a day. Any more than will be eaten up clean should not be given, and the right quantity may soon be found after a few trials. As the young turkeys grow, the food may be increased gradually, although as they run abroad they will pick up a good many insects and some grass, and will not need much more than the quantity above mentioned. A good deal is written about the food for turkeys, and boiled mush, chopped eggs, and a lot of other prepared food, which will give a great deal of trouble, is recommended. This is all unnecessary and even injurious, because it is wholly contrary to the natural needs of these birds, whose proper food consists of insects, seeds, and green vegetable matter. For years past I have never given any other food than the ground mixed grain or wheat crushed in a common coffee mill of a cheap kind, which is very useful to have about any poultry establishment.

When the young turkeys get their full plumage, they may be turned out of the coops and permitted to go as they please. The old hens will prefer to roost in a tree, and will do very well in that way; but a comfortable house with lofty perches, kept specially for the turkeys, and having a suitable yard attached to it, will be found the best. Labor and annoyance is always avoided, in the care of all kinds of poultry, by having easy means of controlling them when it is desired, and leaving them no chance but to do as the keeper desires. When the marketing time comes, the birds are rapidly fattened in coops, being then fed upon corn meal boiled in milk, and made quite thick, so that it is easily eaten. It is not necessary to cram the food down the throats, as is often recommended; this rather retards fattening than helps it, and I have found birds crammed in this way to be several pounds less in weight than others fed, *ad libitum*, in the natural manner. A spring turkey can be made to weigh 16 or 20 pounds by Thanksgiving day or Christmas, and a brood of 10 young ones will thus bring in about $20 at the low price of 10 or 12 cents a pound. The profit of a

dozen broods or so is thus seen to be no small matter for a farmer's daughter to look after, and this sum of money will make a handsome provision for a young maiden who will take the trouble to earn it in this pleasant and agreeable manner. Turkeys are very easily managed; the flock may be driven about quite easily, and if dealt with gently and quietly, they are the most docile of all poultry. I have seen flocks of them driven to market in Kentucky, numbering several hundreds, one man on a mule following, with two boys and a dog to help. It is in this way that the enormous number of these birds, 400,000, it is said, are gathered in Bourbon County, in that State, for the New York market every season, bringing in a handsome sum to the ladies who make a special business of rearing them, and are very successful at it. I have seen a good many large flocks of turkeys thus driven; but none so large as those which a contributor to an English agricultural journal says he has seen, viz., "a mile in length." Possibly he viewed the flock through a glass of a kind in common use in Kentucky, by which it seemed to be strung out to this attenuated and long drawn out extent.

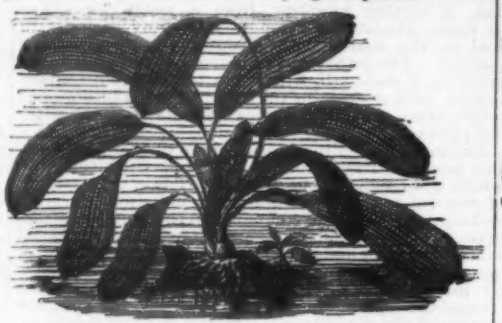
The bronze turkey is the finest of all the varieties, having a reddish golden bronze plumage, and growing when mature to 30 or 40 pounds in weight, and even more when well reared and fed. I prefer the smaller but still good sized Narragansett as the most docile, hardy, and profitable kind. It will easily reach a weight of 15 to 20 pounds when well cared for. The white turkey is very handsome, and a flock on a farmer's lawn is quite ornamental; but it is small and exceedingly tender.—*Country Gentleman.*

THE LATTICE LEAF PLANT.

(Ouvirandra fenestralis.)

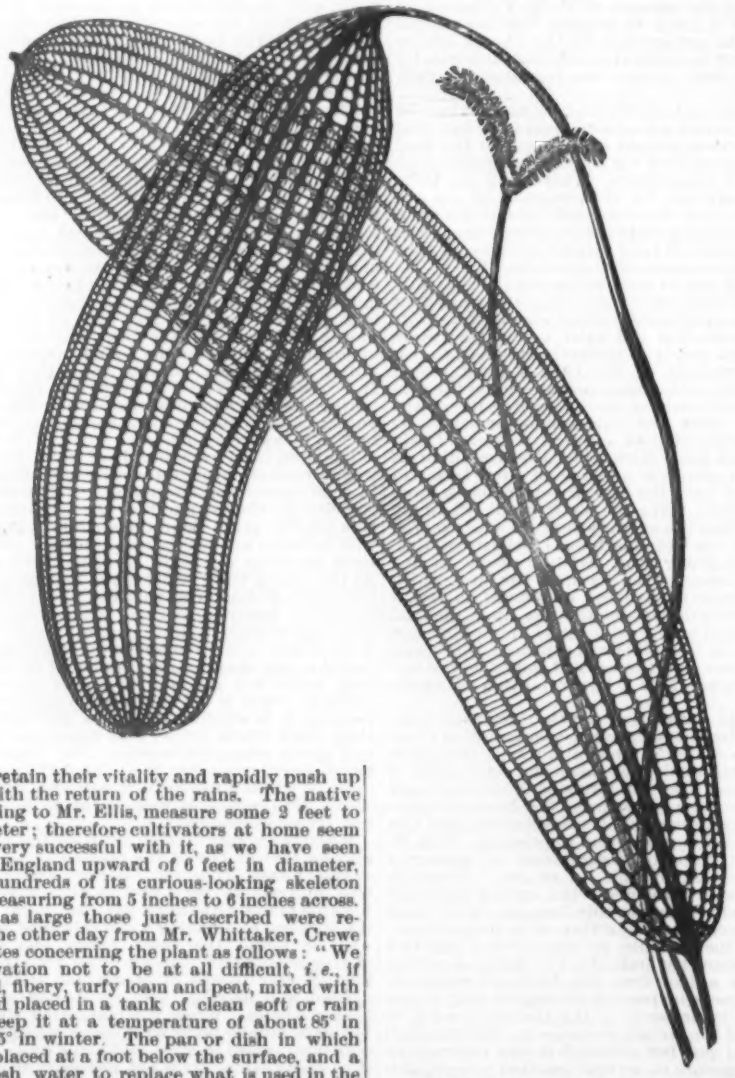
THE lattice leaf plant, of which the annexed are illustrations, is a native of Madagascar, an island which abounds in unique forms of both vegetable and animal life. The existence of this very remarkable plant was first made known by M. Du Petit-Thouars nearly a century ago, but it was not until 1855 that living plants of it reached this country. These were brought by the late Mr. Ellis, who writes as follows concerning this singular plant in its native home: "While staying at Tamatave, I visited a river about eighteen miles distant to see the situation in which the Ouvirandra, or lattice plant, grew. I found it in a sluggish river about 20 yards wide, and 3 yards or 4 yards deep in the center, with a sandy, alluvial bottom, and a considerable deposit of sand and mud around the crowns of the plants, indicating that the deposit of soil brought down by the frequent rains from higher parts of the country formed a sort of top-dressing for the plants."

The Ouvirandra grows in stiff loam or clay—usually near the margin, and about a foot under the surface. It is said to grow in places which at some seasons of the year are dry; when this occurs, the leaves all die, but the roots retain their vitality and rapidly push up new growth with the return of the rains. The native plants, according to Mr. Ellis, measure some 2 feet to 3 feet in diameter; therefore cultivators at home seem to have been very successful with it, as we have seen plants of it in England upward of 6 feet in diameter, and bearing hundreds of its curious-looking skeleton leaves, each measuring from 5 inches to 6 inches across. Leaves nearly as large those just described were received by us the other day from Mr. Whittaker, Crewe Hall, who writes concerning the plant as follows: "We find its cultivation not to be at all difficult, *i. e.*, if potted in good, fibery, turfy loam and peat, mixed with sharp sand and placed in a tank of clean soft or rain water. We keep it at a temperature of about 85° in summer and 75° in winter. The pan or dish in which it is grown is placed at a foot below the surface, and a portion of fresh water to replace what is used in the house is added every day. Under this treatment it grows luxuriantly, and flowers freely every season." Our own experience has been similar to that just quoted. We have found self-sown seedlings of it to grow very freely. We have also grown this lattice plant in inverted cloches placed upon a stage in the stove without any bottom heat, and consequently at a lower temperature than that just named. Under these conditions we have found it to thrive admirably, although it does not grow to so large a size as in heat. People who have no suitable tank are, however, thus enabled to grow it, and, moreover, it can be seen to excellent advantage in this way, especially if the surface of the soil be covered with white Derbyshire spar broken small. Some fresh water should be run into the cloche every day, and the plants should also be well shaded, for when thus exposed on all sides to light, conferva grows rapidly in the water, ultimately fixing itself upon the leaves, and thus not only impairing their appearance, but in the end destroying the plant.



THE LATTICE LEAF PLANT AS IT GROWS UNDER WATER.

O. Bernieriana.—This species was brought unawares to this country along with O. fenestralis by Mr. Ellis, but it is by no means so attractive as the ordinary lattice plant. The leaves of Bernieriana are both longer, narrower, and brighter green than in fenestralis, and the interstices between the ribs are much smaller. It differs from fenestralis, moreover, in producing four spikes of bloom instead of two, and these are rose-colored instead of greenish-white. Judging by the greater length of its peduncles, and by their inflation about the middle, as if to give buoyancy, we should be inclined to believe this species to be a frequenter of deeper water than is usual in the case of fenestralis, notwithstanding its being found accidentally in company with that species. O. Bernieriana first flowered in Messrs. Jackson's nursery at Kingston in 1858.—*W. H. G., The Garden.*



LEAVES OF LATTICE LEAF PLANT.
(Half natural size.)

METALLIC VOLCANO DUST.

AT a recent meeting of the California Academy of Sciences, President Davidson exhibited two vials containing small particles resembling a dark metallic dust, which fell from the air during the eruption of Pabloff (St. Paul) volcano, on the Alaska peninsula. The volcano is situated in latitude 55° 26' and longitude 161° 50'. One of the specimens was gathered at the town of St. Paul, on Kodiak island, by Fred Sargent, of the United States Coast and Geodetic Survey, on a cruise for tidal observation. The other was gathered by Captain Curlee, of the Alaska Company's schooner Kodiak, off Choumagin Island, and forwarded by the United States steamer engaged in the survey. A vessel that was in the vicinity of the eruption at the time it took place, which was in August, will arrive at San Francisco in a few days and bring the particulars. The extent of area over which the dust fell may be partially inferred from the fact that the quantity contained in one of the vials was gathered at a distance of 335 miles from the volcano. Professor Davidson said he had tested the powder with a fine magnet, and found that it took up every particle, and under the microscope he found that they had a metallic luster, and that at least every one in ten contained silica or quartz.

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